Bulletin No. 18

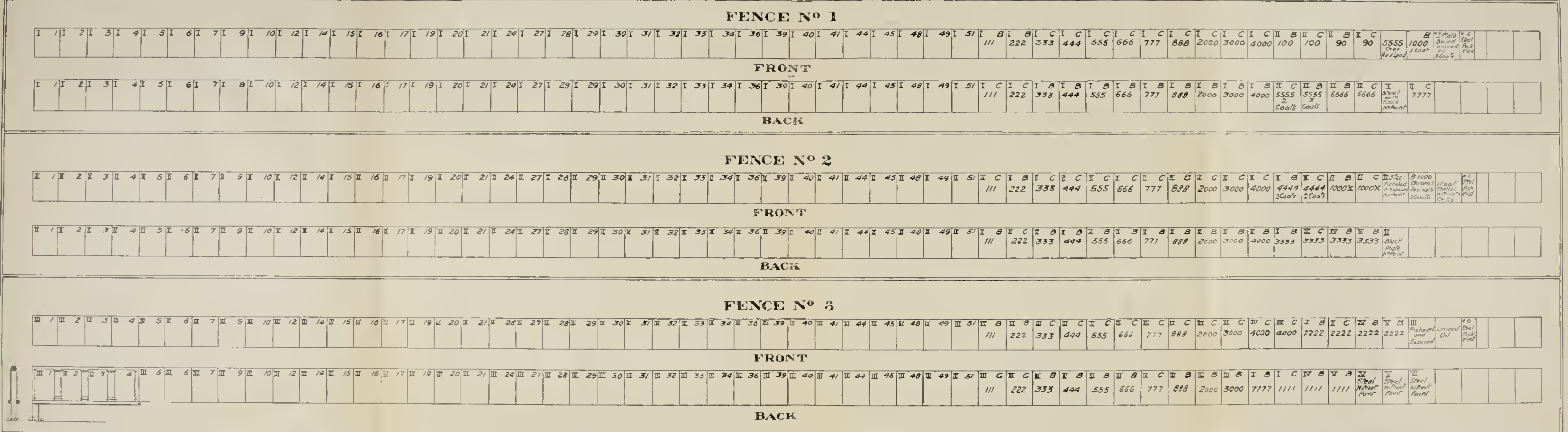
FIRST ANNUAL REPORT ON ATLANTIC CITY STEEL TEST FENCE

BUREAU OF PROMOTION AND DEVELOPMENT
—SCIENTIFIC SECTION—R. S. PERRY, DIRECTOR—
PAINT MANUFACTURERS' ASSOCIATION OF U. S.
3500 GRAYS FERRY ROAD, PHILADELPHIA, PA.

ERECTED, PAINTED AND EXPOSED.
OCT 16, NOV 16, 1908.
LOCATION-DOVER AND VENTNOR AVES.

DIAGRAM
PAINT TEST-STEEL FENCE
ATLANTIC CITY, N.J

H. A. GARDNER
DIRECTOR OF TEST
SCIENTIFIC SECTION
PAINT MANUFACTURERS ASSOCIATION



No 1 Dutch Process White Lead
No 2 Quick Process White Lead
No 3 Zinc Oxide
No 4 Sublimed White Lead
No 5 Sublimed Blue Lead
No 6 Lithopone
No 7 Zinc Lead White

No 9 Orange Mineral American
No 10 Red Lead
No 12 Bright Red Oxide (62 0)
No 14 Venetian Red
No 15 Princes Metallic Brown
No 16 Natural Graphite
No 17 Acheson Graphite

No 19 Lamp Black
No 20 Willow Charcoal
No 21 Gas Carbon Black
No 24 French Yellow Ochre
No 27 Barytes Natural
No 28 Barytes Precipitated
No 29 Calc. Carb. (Whiting)

No 30 Calc Carb Precipitated
No 31 Calcium Sulphate (Gypsum)
No 32 China Clay (Kaolin)
No 33 Asbestine (Silicate Magnesium)
No 34 American Vermilion (Chrome Scarlet)
No 36 Med. Chrome Yellow
No 39 Zinc Chromate

No 40 Zinc & Barium Chromate
No 41 Chrome Green (Blue Tone)
No 44 Prussian Blue (Stimulative)
No 45 Inhibitive Prussian Blue
No 48 Ultramarine Blue
No 49 Zinc & Lead Chromate
No 51 Magnetic Black Oxide

No 90 Straight Lamp Black Paint with Turps & Dryer
No 100 " " Carbon " " " " " "
No 1000 Chrome Resinate in oil
No 2000 1 Coat Zinc Chromate 1 Coat Excluder
No 3000 1 " Lead " " 1 " "
No 4000 1 " Red Lead 1 " "
No 111 Brown Inhibitive Paints

No 222 Black Inhibitive Paints
No 333 White " "
No 444 Green " "
No 555 Black Stimulative Paints
No 666 Brown " "
No 777 White " "
No 888 Green " "

No 1111 Green Special 'G' Formula
No 2222 Red " " "
No 3333 Black " " "
No 4444 A. Excluder Paint
No 5555 Coal Tar Paint
No 6666 Special Paint
No 7777 Special Gl Paint

Analysis of Steel in Plates

	No 1 Fence	No 2 Fence	No 3 Fence	No 4 Fence	No 5 Fence	No 6 Fence
	Bessemer Steel	S. Open Hearth	Pure Iron	Special Bessemer Steel	Special Charcoal Iron	Spellerized Steel
Carbon	.08	.16	05			
Manganese	.35	.44	Mere Trace			
Phosphorous	.08	02	.005			
Sulphur	.05	.024	.024			

Roman Numerals = Class of Steel
Arabic Numerals = Number of Paint

"B" = Black Plates with scale
C = Pickeled Plates

Plates pickeled in Sulphuric Acid were used throughout on the pigments up to #51, using a definate spreading rate of 900 Sq. Ft. per gallon in applying the paint. Above this number, cleaned plates were used with the definate spreading rate as above, and black plates were used without any spreading rate.

First Annual Report on Atlantic City Steel Test Fence

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PREFACE

The information contained within this book will probably be of considerable value to every manufacturer and user of protective coatings for iron and steel. The subject has been gone over in a rather broad manner, and covers the latest phase in the study of corrosion and protective coatings.

R. S. PERRY, *Director.*

CHAPTER I

Results in Recent Testing of Pigments

Study of Corrosion Necessary when Designing Protective Coatings

The many theories, regarding the causes of the corrosion of iron, advanced during the last decade, have stimulated a great amount of original research on this subject by various investigators. In the course of these investigations the subject of protective coatings for iron and steel naturally has been brought into prominence and is receiving a considerable amount of attention.

The study of protective coatings for iron and steel, conversely, has led many interested paint manufacturers and users of painting materials to make a closer study of the causes of corrosion in order that they may know how to make and use better paints for protecting steel. In so doing, they have discovered that the two subjects are intimately connected and vitally important to each other.

A series of very interesting and instructive researches into the nature of the various paint pigments used in the painting of iron and steel, as a determining factor in the corrosion of iron, were recently made, and, as a result of these investigations, it has been possible for certain laws to be formulated, regarding the value of these pigments. Through a previous bulletin of the Scientific Section,

Results of Recent Tests on Nature of Pigments

namely, the "Preliminary Report on Steel Test Fences," the paint trade at large was informed of these investigations, but the results were withheld tentatively for the reason that the Scientific Section had no desire to publish any information, no matter how reliable the source from which it was obtained, without having absolute verification of results.

The tests referred to were made upon fifty pigments largely used in the fabrication of paints, in order to determine which possess stimulative, which inert, and which inhibitive characteristics when in contact with steel in the presence of water. Bulletin No. 35, by Allerton S. Cushman, one of the foremost investigators in this line of research, was recently issued by the Office of Public Roads of the United States Department of Agriculture, and the results of these tests were published therein.

The action of the Scientific Section in refraining from making public this information until published by one of the foremost investigators in this line of research, namely, Dr. Allerton S. Cushman, indicates their ultra-conservative policy, and should free the Scientific Section from any criticism of over-enthusiastic co-operation in this work. In order to explain to the members of the Association the present status of our work along these lines, it seems advisable to publish at this time the results so far obtained and to offer any new information that may be of benefit to individual co-workers.

The paint manufacturer has drawn attention to the fact that some of these pigments which, in water, cause marked corrosion, when painted out in oil, give steel and iron immunity from corrosion for some period. The excluding value of such pigments may account for their protection for a certain time. However, when the film of oil has been destroyed, the pigment is subject to the moisture which acts to stimulate corrosion.

The following table is printed in Bulletin No. 35, by Allerton S. Cushman, of the United States Department of Agriculture:

BASIC CLASSIFICATION OF PIGMENTS

INHIBITORS	INDETERMINATES	STIMULATORS
Zinc Lead Chromate	White Lead (quick process, Basic Carbonate	Lamp Black
Zinc Oxide	Sublimed Lead (Basic Sulphate)	Precipitated Barium Sulphate (Blanc Fixe)
Zinc Chromate	Sublimed Blue Lead	Ocher
Zinc and Barium Chromate	Lithopone	Bright Red Oxide
Zinc Lead White	Orange Mineral (American)	Carbon Black
Prussian Blue (Inhibitive)	Red Lead	Graphite No. 2
Chrome Green (Blue tone)	Litharge	Barium Sulphate (Barytes)
White Lead (Dutch process)	Venetian Red	Graphite No. 1
Ultramarine Blue	Prince's Metallic Brown	Chinese Blue (Stimulative Prussian)
Willow Charcoal	Calcium Carbonate (Whiting)	
	Calcium Carbonate (precipitated)	
	Calcium Sulphate	
	China Clay	
	Asbestine	
	American Vermilion	
	Medium Chrome Yellow	

The following table gives the results obtained by the different investigators in determining by an accelerated test the relation of the various paint pigments in their effect on iron and steel in the presence of water. The losses

LOSS OF STEEL IN GRAMS IN TESTS CARRIED OUT ON PIGMENTS TO ASCERTAIN THEIR VALUE AS RUST INHIBITORS

	Pigment	Gardner No. 1 20 days	Cushman Nos. 1 & 2 10 days	Walker P. H. No. 2 7½ days	Cushman No. 2 10 days	Walker W. H. No. 1 ——	Aver'ge
1	Zinc Chromate	.0050	.0300	.0094	.0130	.0396	.0194
2	Zinc and Barium Chromate	.0153	.0468	.0034	.0140	.0351	.0229
3	Zinc and Lead Chromate	.0094	.0277	.0153	.0085	.0620	.0246
4	Zinc Oxide	.1524	.0296	.1002	.0085	.0504	.0682
5	Zinc Lead White	.0842	.1712	.0515	.0856	.0456	.0876
6	Barium Chromate	.2333	.0101	.0429	.0094	.1932	.0978
7	Ultramarine Blue	.0247	.3185	.0137	.1865	.0496	.1186
8	Chrome Green (blue tone)	.0860	.2269	.0548	.1240	.2346	.1453
9	Prussian Blue Inhibitive	.1438	.2267	.0448	.1130	.2671	.1591
10	Lithopone	.0160	.3791	.1274	.1792	. . .	.1754
11	Willow Charcoal	.1694	.2795	.1439	.1362	.2110	.1880
12	Litharge	.4325	.1932	.0309	.1584	. . .	.2038
13	Dutch Process White Lead	.2040	.2895	.1781	.1150	.2743	.2122
14	Quick Process White Lead	.2120	.3352	.1288	.1848	.2274	.2176
15	Calcium Sulphate	.3966	.2143	.1759	.1597	.2174	.2328
16	Prince's Metallic Brown	.3774	.2620	.1983	.1408	.1974	.2352
17	Orange Mineral French	.3950	.2724	.1495	.1467	.2526	.2432
18	Calcium Carbonate (Whiting)	.3828	.3620	.1384	.2380	.1208	.2484
19	Sublimed Blue Lead	.3177	.3425	.1001	.2365	. . .	.2492
20	Lemon Chrome Yellow	.2767	.4067	.1365	.1972	. . .	.2543
21	Orange Chrome Yellow	.2826	.4203	.1700	.1907	.2150	.2557
22	Medium Chrome Yellow	.4090	.3767	.1319	.1763	.2288	.2645
23	Chrome Green (yellow)	.3265	.3670	.1348	.1453	.3521	.2651
24	Venetian Red	.2682	.4756	.1955	.2375	.1564	.2666
25	Bone Black	.3392	.3245	.0921	.1413	.4401	.2674
26	Asbestine	.2394	.4025	.1748	.2240	.3405	.2762
27	Keystone Filler	.3560	.4651	.1366	.3349	.1481	.2881
28	Orange Mineral American	.4416	.4336	.1719	.2065	.2315	.2970
29	Umber	.1365	.5961	.1498	.3817	.2403	.3009
30	China Clay	.3493	.4770	.1248	.2445	.3212	.3034
31	Calcium Carbonate Precipitated	.3574	.4910	.1828	.2625	.2616	.3111
32	Red Lead	.3112	.3555	.1495	.1717	.5707	.3117
33	Prussian Blue Neutral	.3584	.4463	.1218	.2415	.4173	.3171
34	Indian Red	.3546	.3739	.2617	.1905	.4334	.3228
35	American Vermilion	.4328	.4147	.2612	.1877	.3387	.3270
36	Sublimed Lead	.4176	.5856	.0982	.2372	.3116	.3300
37	Sienna	.2876	.5432	.2949	.3085	.4462	.3761
38	Naples Yellow	.6482	.4800	.1512	.2347	.3846	.3797
39	Prussian Blue Stimulative	.5113	.4559	.2055	.2195	.5202	.3825
40	Mineral Black	.3050	.8018	.2017	.3529	.3353	.3993
41	Barytes	.4454	.5883	.2547	.3841	.5636	.4472
42	Natural Graphite	.4342	.5437	.2606	.3173	.7165	.4545
43	Bright Red Oxide	.3878	.7896	.2920	.3707	.4429	.4566
44	Acheson Graphite	.5262	.6337	.3723	.2789	.5095	.4641
45	Ochre	.4022	.8408	.2119	.4315	. . .	.4716
46	Carbonith White	.2655	. . .	. . .	. . .	.7152	.4904
47	Carbon Black	.5003	.6955	.4069	.3751	.5716	.5099
48	Precipitated Blanc Fixe	.5247	.8806	.3132	.5085	.5064	.5467
49	Lamp Black	.7180	1.3098	.2838	.7096	.6257	.7294

in weight measure the amount of corrosion. The most inhibitive head the list and the most stimulative are at the bottom.

CHAPTER II

Pigments in Aqueous vs. Oil Medium

Objections Offered to These Tests

Some objections were made by chemists to the tests of the different pigments in water medium, on the ground that pigments which might stimulate corrosion in the presence of water would not do so in oil medium. Claims were made that oil acts as an envelope for the pigment particles, and being a non-conductor of electricity, prevents any electrolytic action taking place on the steel plates upon which they are painted out.

Tests Made with Pigments in Oil

These objections suggested to Mr. H. A. Gardner, Asst. Director of the Scientific Section, some rather interesting experiments, and his report is as follows: "Upon several slides of glass, such as are used for mounting microscopic specimens, were painted out various pigments ground in oil. Upon these plates of glass thus painted and after they were properly dried, were firmly secured small strips of copper at either end. To the ends of the strips of copper were attached the wires of an ordinary dry cell. Into this circuit was placed a very delicate galvanometer. It was found that absolutely no current flowed through the paint film, and the galvanometer needle remained in its original position, at zero.

Results Confirm Previous Work

"The glass slides were then removed from the apparatus and immersed in water for a

while, during which time they were penetrated by the water to a certain extent, thus duplicating in a quick way the action of rainstorms upon paint coatings over an extended period. The slides were removed from the water and, after being carefully wiped off, were again connected up in the apparatus.

Conductivity of Moist Films by Stimulative Pigments

"It was then found that certain pigments which are good conductors of electricity permitted the current to flow, and the galvanometer needle was deflected to quite an extent. On the other hand, in the case of pigments which are absolutely non-conductors of electricity, there was no movement of the needle. As would be expected, those pigments which caused deflection of the galvanometer, such as the carbonaceous group, were in the active stimulative class, while those which prevented the deflection of the galvanometer needle were in the inhibitive class. These results confirm Dr. Cushman's results regarding the nature of such pigments. Corrosion in structural steel in situ appears to be dependent largely upon what Dr. Thompson, in commenting on the work of Cushman, Walker and others, has aptly designated "auto-electrolysis"—that is, electrolysis due to currents set up between areas having different potentials in the material itself. These currents require the presence of an electrolyte to serve as a conductor and thus complete the electrical circuit. It thus appears probable that a paint film which, when moistened, becomes a good conductor of electricity, may serve as an active aid to corrosion through physical quality alone."

Non-Conductivity of Moist Films of Inhibitive Pigments

CHAPTER III

Results of Inspection of Steel Test Fences

As explained in the "Preliminary Report on Steel Test Fences," in order to make a practical field test of the value of various pigments, it was decided by the Paint Manufacturers' Association to erect steel test fences at Atlantic City, upon which to paint out in oil medium all the pigments which previously had been tested out by so many investigators in aqueous medium.

Steel Test Fences for Practical Field Test of Value of Various Pigments

The work was carried out with the greatest care by the Scientific Section and was under the supervision of Committee E, on Preservative Coatings, and Committee U, on Iron and Steel, of the American Society for Testing Materials. The Master Painters' Association of Pennsylvania was also represented in the work.

In the front of this book will be found a chart of the fences, showing the placement of every panel and giving the formula of the paint applied thereon. This chart will be of considerable value to anyone desirous of making a personal investigation of the fence.

A recent inspection of the fences indicated that it was too early to make a report, but a few observations recently made, may not be out of place at this time.

Condition of White Lead, Zinc Oxide, Oxide of Iron Paints

It was found that the white lead and zinc oxide pigments appeared to have thus far given excellent protection to the steel and iron upon which they were painted. The pure white lead, however, has shown tendency to chalk, while in some cases the zinc oxide has shown tendency toward checking. The red iron oxides applied to the steel plates seemed to be in good condition, with the possible exception of Venetian red on which there seemed to be a very slight exudation or leaching out of the calcium sulphate contained in this pigment.

Condition of Carbonaceous Paints

An examination of the graphite, lamp black and carbon black films showed that it was too early to report on their value. These films are still intact and the color prevents close examination of the underlying surface. However, it was observed that wherever the plates, which were painted with these pigments, had been abraded to the least degree, very active corrosion had started, and appeared to be spreading underneath the paint coating.

Inhibitive Pigments Standing Well

The plates painted with red lead were in excellent condition, as were also those painted with zinc chromate and zinc-and-barium chromate. In the case of the plates painted with zinc chromate, several abrasions made at the time of erecting the fence disclosed the clean steel plate which had suffered practically no corrosion. This, presumably, is due to the fact that zinc chromate being slightly soluble had kept the abraded places in a passive state and prevented any rust forming thereon. The

Value of Chromium Pigments

plates painted with chromium resinate seem to be in excellent condition, and the high efficiency of this pigment as a water excluder may prove it to be a valuable ingredient of a protective paint coating.

Prime Coaters

The plates, which were primed with various inhibitive pigments and topped with the same second-coater, have not shown as yet any definite results which would indicate which pigment to use as a prime coating material.

Defects Observed on Coal Tar Paints

The plates, which were coated with red lead and second-coated with bitumen and coal tar paints disclosed a most marked alligatoring of the top coats, through which the red lead used as a prime coater could be distinctly seen. Unequal expansion of the two coats is probably responsible for this fault.

Marked Rust Acceleration on Plates Coated with Gypsum

Those plates painted with calcium sulphate (gypsum) showed the most marked corrosion, the plates showing a brown coating of oxide of iron working itself completely under the coating.

Natural and Artificial Barium Sulfate and Calcium Carbonate

It was noticed that calcium carbonate and barium sulphate, both in the precipitated form, as applied to the steel panels, exhibited considerable chalking, while calcium carbonate and barium sulphate in their natural state, as whiting and barytes respectively, were standing up much better, no chalking being evident. The precipitated forms of calcium carbonate and barium sulphate gave the greatest hiding power, being quite opaque, while the natural forms, were very transparent.

The several samples of steel which were exposed unpainted after having been pickled showed varied degrees of corrosion, but it is too early as yet to report upon these plates. However, those plates which were exposed unpainted, but having the mill scale showed more rapid corrosion and more pitting than those plates not having the mill scale; in fact some of these plates having the mill scale corroded in certain spots in an extremely rapid way, leaving certain areas with the mill scale unacted upon. The mill scale in this case would act as a surface upon which the hydrogen evolved during the electrolytic action which accompanies the process of corrosion could be catalyzed to form water, thus allowing the corrosion to proceed very rapidly. This bears out the statement of Dr. W. H. Walker, Prof. of Industrial Chemistry at the Mass. Inst. of Technology, regarding the function of oxygen in the corrosion of iron and the action of mill scale as a depolarizing surface.*

Rate of Corrosion on Various Unpainted Plates

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*This recalls some recent work done by Dr. Walker in which he finds linseed oil to be, under certain conditions, an accelerator of corrosion. He found that when a steel or iron surface painted with linseed oil became abraded in any particular spot, corrosion would proceed more rapidly in the presence of the coating of oil than without the coating. This he ascribes to the fact that the hydrogen, which is evolved during the corrosion is removed immediately by the linseed oil, which (being an unsaturated hydrocarbon) has an enormous power of absorbing the hydrogen and acts very much in the same way as mill scale in destroying the "electrolytic double layer," so-called. In the event, however, of the linseed oil containing different pigments there is a marked difference in the ability of the linseed oil to remove the hydrogen with sufficient rapidity to accelerate corrosion.

Wherever an abrasion appeared upon the paint coatings of the various panels, different results were noted. In the case of panels which were painted with certain stimulative materials, abrasions showed progressive corrosion had proceeded and pitting was evident, while in the case of panels painted with high power inhibitive materials, the steel was in very good condition.

Scratching Plates to Observe Action of Oil Coatings

In order to give this new development in the study of the corrosion of iron a practical field test, each plate on the steel test fences has recently been scratched at the lower right hand corner, using the same instrument in each case. The painted surfaces being thus abraded, the progress of the corrosion will be carefully watched and most interesting data may be recorded later on as regards the value of each pigment in linseed oil in checking any accelerative action which may be exerted by the linseed oil.

CHAPTER IV

Excluding and Water-Resisting Properties of Paints

Besides considering the pigments as stimulators and inhibitors, a most careful study has been made by the Scientific Section as to the value of various pigments as excluders or moisture resisters.

Excluders and Water Shedders

An excluding paint is one that has the property of excluding and preventing the admission of moisture to the steel, thus depriving the steel of the moisture which is essential to corrosion. A water-shedding paint is one which has the property, because of certain physical characteristics, of shedding water, and plates painted with such paints often appear dry immediately after a rain storm. Pigments greasy and unctuous in nature make good water-shedding paints. They may or may not have excluding values.

Properties of Excluding Paints

The excluding properties of a paint coating are largely dependent upon the composition of the vehicle. It has been proved beyond doubt that a vehicle the interstices of which are filled up with fused gum is superior in its water excluding properties. Some excluders do not have the property of moisture shedding, and observations have been made of

several plates painted with natural excluding materials which did not shed water, but which were the most perfect water excluders. Ordinarily linseed oil, when painted out and dry, is neither an excluder nor a moisture resister, as the tackiness of the film will show after a rain storm. A peculiar blistering appearance is also shown on the surface, showing where rain drops have acted upon the vehicle and penetrated through, leaving the coating soft and pliable and sometimes raising many blisters thereon.

Water Shedders Not Always Permanent

Considerable value has been attached to certain protective coatings whose only real virtue was that of being able to resist the action of rain and water, but which would ultimately break down in a very rapid way, allowing deep penetration by the water. The water shedding pigments which we have mentioned as being greasy in nature or unctuous, serve sometimes, when made into paints, as good protective coatings for a time, but sooner or later fail completely in their object.

How Moisture Goes Through a Paint Film

It has often been asked, in what manner does water penetrate a paint coating? When the coating is comparatively new and the linoxyn intact, the water goes through probably in two ways: either by forming a solid solution with the linoxyn coating itself and becoming a part of the paint, or by diffusing through the linoxyn, which is really a porous membrane.

Thus it would appear that the use of dif-

ferent pigments would produce more or less permeable films, according to the proportion of space filled up in the vehicle.

Properties of Different Pigments in Retarding Moisture Penetration

That certain pigments do have the power of preventing to a certain extent more than others the admission of water through a paint coating, the following series of experiments, designed by Mr. Gardner, seem to prove. His report is as follows:

Films made of Paints Used on Steel Fences

"A series of paint films were made from many of the pigments which were used in painting the Atlantic City test fence. These paints contained the pigment ground in two-thirds raw and one-third boiled oil, without drier, and the films were painted out in three-coat work, allowing ample time between each coat for proper drying. No method has yet been devised for securing paint films of absolutely the same thickness, but the greatest care was taken in making these films to have them all approximately the same thickness.

Arrangement of Tests

"Small bottles, like that shown in the illustration, were half filled with concentrated sulphuric acid and paint films were hermetically sealed over the mouths with Canada balsam. These bottles, numbered, were then accurately weighed on delicate chemical balances and afterward exposed under a large bell jar, all at the same time. This bell jar was so fixed that it could be saturated with moisture and kept under constant temperature. At the end of a week the bottles were removed and carefully weighed again. The increase in weight indicated the amount of moisture which had pen-

etrated the film in each case and which was taken up by the sulphuric acid, by absorption.

Results of Moisture Absorption Tests

"The test was kept up for forty-nine days, making weighings every seven days. The figures in the table indicate the amount, in grams, of moisture taken up. The pigments

"MOISTURE EXPERIMENTS"

FIGURES GIVEN EXPRESS GAIN IN WEIGHT, *e. g.*, WATER ABSORBED

	7 days	14 days	21 days	28 days	35 days	49 days
Iron Oxides (with 2% Zinc Chromate and 2% Chrome Resinate)	0.032	0.048	0.072	0.092	0.110	.140
Dutch White Lead	0.040	0.078	0.111	0 162	0.187	.264
White Lead and Zinc Oxide	0.043	0.081	0.115	0.163	0.192	.266
China Clay	0.044	0.086	0.122	0.182	0.219	.317
Whiting	0.044	0.079	0.114	0.167	0.197	.277
Zinc Oxide, Barytes and Blanc Fixe	0.048	0.092	0.125	0.183	0.190	.290
Zinc Lead White	0.049	0.095	0.130	0.181	0.211	.284
Red Lead	0.049	0.092	0.130	0.187	0.215	.295
Basic Sulphate-White Lead	0.049	0.092	0.128	0.185	0.213	.292
Zinc Oxide and Whiting	0.060	0.110	0.156	0.221	0.256	.352
Zinc Chromate	0.064	0.121	0.176	0.270	0.298	.417
Barytes and Zinc Oxide	0.064	0.118	0.169	0.240	0.278	.386
Zinc Oxide	0.065	0.122	0.172	0.244	0.285	.391
Calcium Sulphate	0.066	0.140	0.212	0.313	0.377	.555
American Vermilion	0.069	0.140	0.202	0.311	0.349	.501
White Lead, Barytes and Blanc Fixe	0.074	0.137	0.200	0.294	0.344	.490
Barytes	0.074	0.138	0.202	0.298	0.336	.466
Willow Charcoal	0.077	0.154	0.236	0.378	0.459	.694
Lithopone	0.083	0.156	0.228	0.332	0.380	.550
Carbon Black	0.084	0.168	0.250	0.391	0.448	.654
Lead and Zinc Chromate	0.086	0.161	0.226	0.319	0.369	.497
Chinese Blue Stimulative	0.092	0.185	0.276	0.405	0.470	.671
Venetian Red	0.093	0.190	0.279	0.418	0.508	.770
Natural Graphite	0.104	0.223	0.350	0.539	0.632	.951
Medium Chrome Yellow	0.106	0.207	0.300	0.429	0.505	.725
Bright Red Oxide	0.116	0.240	0.365	0.548	0.662	.976
Barium and Zinc Chromate	0.116	0.211	0.298	0.430	0.481	.660
Ultramarine	0.119	0.230	0.336	0.484	0.578	.814
Prussian Blue Inhibitive	0.125	0.246	0.361	0.521	0.619	.733
Raw Linseed Oil	0.143	0.300	0.449	0.679	0.803	1.201
Lampblack	0.199	0.411	0.641	1.033	1.234	1.873
Blanc Fixe	0.210	0.472	0.744	1.144	1.414	1.944

have been arranged with regard to the most perfect excluders at the top, followed by those which are less efficient as excluders. As will be noted in the table, the tests all the way through were confirmed at each weighing. At the head of the list stands iron oxide, which contains chromium resinate in small proportion. It will be found by careful observation of the list of pigments in the table that iron oxide by itself falls near the middle, but by the addition of 2 per cent. of chromium resinate, which acts as a gum to seal up the interstices of the pigment, this pigment has been rendered the most excellent water excluder that we have."

SUPPLEMENT

The steel wire fences erected in Pittsburg, under the direction of Dr. Cushman, and painted by the Scientific Section, are showing some interesting results. The cut shows a section of wire painted with a stimulative carbonaceous paint. The marked corrosion going on seems to indicate that the most inhibitive paints only should be used for painting iron and steel.

A further description of the steel wire panels may be found in Bulletin No. 35, by Dr. Cushman, of the Office of Public Roads, U. S. Dept. of Agriculture.

Section of wire painted with a stimulative carbonaceons paint

CATALOGUE

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Publications of the Scientific Section

BUREAU OF PROMOTION AND DEVELOPMENT

PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

Bulletin Number

Preliminary Booklet—Addresses on Paint, Delivered Before the Michigan Chapter, American Institute of Architects, 1907.

1—Tables of White Pigments and Vehicle—Standard Nomenclature.

2—Standard Can Sizes Recommended to Paint Manufacturers.

3—First Report on the Test Fences Erected by the Scientific Section. (Out of print.)

4—Methods for the Analysis of the Vehicle Constituents of Paint.

5—Tests Upon the Corrosion of Iron to be Conducted by the Scientific Section. (Out of print.)

6—First Annual Report of the Scientific Section.

7—Preliminary Report on Steel Test Fences.

8—Report of Committee "E" on Preservative Coatings for Iron and Steel.

9—Recent Technical Developments in Paint Manufacture.

10—Protective Coatings for Conservation of Structural Material.

11—The Corrosion of Iron and Steel. *By Alfred Sang.* (Out of print.)

Bulletin
Number

12—The Function of Oxygen in the Corrosion of Metals. *By William H. Walker.*

13—Protective Coatings for Steel and Iron. *By Robert S. Perry.* (Out of print.)

14—Coatings for the Conservation of Structural Material. (Out of print.)

15—Protective Coatings for Structural Material. *By R. S. Perry.*

16—First Annual Report on Wearing of Paints Applied to Atlantic City Test Fence.

17—First Annual Report on Wearing of Paints Applied to Pittsburg Test Fence.

18—First Annual Report on Atlantic City Steel Test Fence.

19—Laboratory Study of Panels on Atlantic City and Pittsburg Test Fences. (In press.)

BUREAU OF PROMOTION AND DEVELOPMENT
PAINT MANUFACTURERS' ASSOCIATION OF THE U. S.
SCIENTIFIC SECTION
HENRY A. GARDNER, Director
3500 Grays Ferry Road, Philadelphia, Pa.

The enclosed Bulletin makes a tentative report on the condition of the various groups of pigments applied to the Steel Test Fence at Atlantic City, N. J.

Some new experiments on the Conductivity of Moist Paint Films, and the Excluding Value of Different Pigments in Oil, are described in Chapters II and III. Results of these experiments, together with the list of pigments as printed on page 8, in which they are charted in order of their inhibitive value, should give the paint manufacturer definite knowledge for future use in designing protective coatings for Iron and Steel.

HENRY A. GARDNER, *Director.*

Bulletin No. 19

Laboratory Study of Panels of Atlantic City and Pittsburg Test Fences

SCIENTIFIC SECTION
HENRY A. GARDNER, Director
BUREAU OF PROMOTION AND DEVELOPMENT
PAINT MANUFACTURERS' ASSOCIATION
3500 Grays Ferry Road
Philadelphia, Pa.

Charted results of Laboratory Inspection of Atlantic City and Pittsburg Test Fence Panels

Location of Fence	Formula Number	Chemical Analysis: Basic Carbonate White Lead	Basic Sulfate White Lead	Zinc Oxide	Zinc Lead White	Calcium Carbonate	Calcium Sulfate	Magnesium Silicate	Barytes	Blanc Fixe	Silica	Color	Chalking	Abrasion Resist (Pounds of Emery)	Checking and Appearance under Microscope
A C	1	34		66								4	1	24	PAINT FILM ALMOST INTACT NOTE THE TRI-ANGULAR CHECKING CHARACTERISTIC OF ZINC OXIDE IN THE EARLY STAGES OF FORMATION
P	1	34		66								20	6	28	SMOOTH SURFACE
A C	2	50		50								5	5	20	COMBINATION CRACKING OF TWO INTIMATELY MIXED AND EVENLY PROPORTIONED PIGMENTS
P	2	51		49								21	9	25	VERY SLIGHT EVIDENCE OF CHECKING
A C	3	16	30	44		10						3	6	36	USUAL IRREGULAR CHECKING OF A COMPOSITE PAINT
P	3	24	19	46		11						8	6	42	SCARS SHOWING WHERE IMPURITIES HAD SETTLED
A C	4	49		48		3						4	7	31	CRACKS PERCEPTIBLE
P	4	49		48		3						11	4	30	SLIGHT EVIDENCE OF CHECKING ALONG THE GRAIN OF WOOD
A.C.	5	21		49		4		26				4	1	31	BREAK DOWN ADVANCING SLIGHTLY ALONG THE GRAIN OF THE WOOD
P.	5	21		52		2		25				15	3	25	SMOOTH SURFACE
A.C.	6			63					37			5	7	29	NUMEROUS SHORT, THIN AND IRREGULAR SURFACE BREAKS
P.	6			63					37			21	2	31	SMALL FOREIGN PARTICLES STILL ADHERING
A.C.	7	45		55								4	8	18	CLOSELY FOLLOWS THE LINES OF CRACKING DISPLAYED IN Nº 4
P.	7	37		63								15	6	24	SMOOTH SURFACE
A C	*8	38		48							14	4	1	36	OUTER SURFACE ONLY SLIGHTLY SERRATED
P	*8	38		48							14	13	3	41	SMOOTH SURFACE
A C	9			75		3					22	6	2	5*	COMBINATION BROAD ANGULAR CHECKING DISPLAYING CHARACTERISTICS BOTH OF ZINC OXIDE AND SILICA
P	9			75		2					25	20	2	19	SMOOTH SURFACE
A C	10	43		43		8		6				4	3	21	CRACKING SHALLOW AND THREAD-LIKE FOLLOWING THE GRAIN OF THE WOOD
P	10	45		45		5		8				8	6	29	SMOOTH SURFACE
A C	11	49		51								4	3	23	IRREGULAR SHORT AND FAIRLY DEEP
P	11	51		49								19	5	33	FOREIGN PARTICLES STILL PRESENT A FILM
A C	12	61		34							5	5	6	24½	MEDIUM CHECKING OF A GENERAL NATURE, BUT SUPERFICIAL
P	12	61		35							4	23	6	24	BEGINNING ALONG THE GRAIN OF THE WOOD
A C	13		57	31		4		8				4	3	17½	THREADS ADVANCING ALONG THE GRAIN OF THE WOOD
P	13		59	29		4		8				12	7	24	SMOOTH SURFACE
A C	14	25	16	27		4	28					5	6	14	PECULIAR EROSION-LIKE EFFECT SPREADING OVER THE ENTIRE SURFACE
P	14	24	20	27		5	24					12	8	28	MOTTLED EFFECT DUE TO FOREIGN PARTICLES
A C	*15	20		40	30	10						5	9	8	FOLLOWING THE LINES AND GENERAL APPEARANCE OF Nº 20 THO SLIGHTLY MORE ADVANCED
P	15	20		41	29	10						12	8	35	SMOOTH SURFACE
A C	16	34		35					31			8	3	16	CHECKING FOLLOWS LINES OF Nº 6
P	16	32		34					34			15	6	25	SCARS ARE PLAINLY EVIDENT
A C	17	37		43				1	13	4		5	8	13	SLIGHT CRACKS OF AN ERUPTIVE NATURE TEND TO FOLLOW GRAIN OF WOOD
P	17	37		42				8	14	4		11	6	19	SCARS EVIDENT
A C	18	29		21								4	6	17	SOMEWHAT WIDELY SEPARATED FISSURES OF SLIGHTLY MORE THAN THE MEAN DEPTH
P	18	78		22								15	9	31	SMOOTH SURFACE
A C	19		66	34								4	6	14	NUMEROUS AND DEEP THREE CORNERED CRACKS GRADUALLY UNITING A DOMINATION OF THE ZINC OXIDE CHARACTERISTICS OVER THAT OF THE BASIC SULPHATE
P	19		66	34								7	10	31	SMOOTH SURFACE
A C	20	66		19		10		8				5	3	20	THIN IRREGULAR UNUNITED THREADS SHOWING THE VALUE OF REINFORCING PIGMENTS
P	20	67		20		10		3				19	8	28	SMOOTH SURFACE
A C	33	17	20	33							30	6	8	39	DEEP, BROAD, HEXAGONAL CHECKS DO NOT EXTEND TO THE WOOD BUT SIMPLY GIVE A VEINED APPEARANCE A TOUGH UNDER SURFACE EXISTS
P	33	14	25	32							30	10	8	41	SCARRED APPEARANCE EVIDENT
A C	34	36	7	36		18			3			5	2	21	SHOWING THE SURFACE EFFECT DUE TO INITIAL BREAKDOWN
P	34	38	8	34		19			5			6	7	39	CHECKING EVIDENT
A C	35	38	5	27		20			10			5	2	26	SURFACE CHECKING OF MINOR NATURE
P	35	39	8	25		19			9			6	5	42	SMOOTH APPEARANCE
A C	36	100										6	10	6	GENERAL CHARACTERISTIC CRACKING OF WHITE LEAD WITH VERY ROUGH SURFACE
P	36	100										15	10	26	CHECKING ADVANCING IN THE USUAL WAY
A C	37	100										5	10	7½	NETWORK OF DEEP AND IRREGULAR FISSURES CHARACTERISTIC OF WHITE LEAD
P	37	100										15	10	26	CHECKING ONLY SLIGHTLY EVIDENT
A C	38	100										4	10	8	GENERAL NETWORK-LIKE CRACKING HIGHLY PRONOUNCED AS IN FORMULA Nº 37
P.	38	100										14	10	24	CHARACTERISTIC CHECKING OF WHITE LEAD VERY APPARENT
A C	39				100							7	8	12	TRACES OF FINE THREAD-LIKE CRACKING ALMOST NEGLIGIBLE
P	39				100							20	2	58	SMALL PARTICLES OF FOREIGN MATTER APPARENT
A C	40		100									4	10	7½	SMOOTH EVEN SURFACE FREE FROM CHECKING
P	40		100									13	10	31	SURFACE FREE FROM CHECKING
A C	45			91		9						5	1	24	TRIANGULAR CRACKING OF ZINC OXIDE PLAINLY EVIDENT THOUGH NOT SO PRONOUNCED AS IN PURE ZINC OXIDE, DUE TO REINFORCING MATERIAL
P	45			91		9						8	1	56	SMOOTH SURFACE
A C	46			63					37			8	7	33	DENSE AND DIVERSE FISSURES OF MEAN DEPTH
P.	46			61					39			10	2	36	SCARRED APPEARANCE
A C	47			100								4	1	38	USUAL TRIANGULAR CRACKING OF SEMI-DEPTH
P	47			100								6	1	51	SMOOTH SURFACE

*SURFACE BRITTLE NOT LIKE PITTSBURG. LOW ABRASION RESIST DUE TO EXCESSIVE CRACKING

*TENTATIVE

Laboratory Study of Panels Atlantic City and Pittsburg Test Fences

SCIENTIFIC SECTION
HENRY A. GARDNER, Director
BUREAU OF PROMOTION AND DEVELOPMENT
PAINT MANUFACTURERS' ASSOCIATION
3500 Grays Ferry Road
Philadelphia, Pa.

PREFACE

THE importance of making tests of precision to control the results of the First Annual Inspection of the Pittsburg and Atlantic City Test Fences, by microscopic and other detailed investigations, and the possibility of selecting characteristic areas from the various panels and erecting small duplicate test fences in the laboratory were suggested by Mr. R. S. Perry, and to him is due the credit for many of the methods used, which are outlined herein.

The results are extremely interesting and present data heretofore unpublished, which apparently justify the ultimate value of the combination type of formula.

HENRY A. GARDNER, Director

CHAPTER I

Test Fence Committees

The Atlantic City Test Fence was visited on July 13th, 1909, by the following members of the Test Fence Committees:

Dr. Robert Job, Chairman, Sub-Committee of Committee E, American Society for Testing Materials;

Mr. George Butler, Official Painter, Master House Painters and Decorators of Philadelphia;

Mr. H. A. Gardner, Director, Scientific Section, Bureau of Promotion and Development, Paint Manufacturers' Association of United States;

Dr. John A. Schaeffer, member Test Fence Committee, Carnegie Technical Schools.

Later in the month the Pittsburg Test Fence was visited by:

Mr. A. C. Rapp, Chairman, Test Fence Committee, Pittsburg Branch, Master Painters' Association;

Dr. J. H. James, Chairman, Test Fence Committee, Carnegie Technical Schools;

Dr. John A. Schaeffer, member Test Fence Committee, Carnegie Technical Schools;

Mr. H. A. Gardner, Director, Scientific Section, Bureau of Promotion and Development, Paint Manufacturers' Association of United States.

The panels were carefully looked over and upon each was marked out a representative portion, care being exercised to select areas where previous inspections had not disturbed the surface of the film in any manner. The inspectors then placed the numbers of the panels upon the areas which had been marked off, and also placed their initials thereon. The carpenter sawed out the sections marked, and, after wrapping them in tissue paper, handed them to the inspectors, who transferred them to the laboratory.

In the laboratory the panels were placed upon models of the respective fences from which they had been removed, and, being thus set up, the laboratory investigations were begun.

The illustration shows the model test fences set up together. It is very apparent that the Pittsburg panels are much the darker in color, due to the soot and in some cases lead sulfide deposited on their surface. The cuts show in detail a panel from each fence, with the number thereon, and the inspectors' initials.

PANELS FROM PITTSBURG TEST FENCE | PANELS FROM ATLANTIC CITY TEST FENCE

CHAPTER II

Reports from Chairmen of Committees on Selection of Characteristic Areas

It was considered advisable when having the panels removed from the fence for laboratory work that everything be done under the most careful surveillance of the different committees so that no future question could be raised as to the legitimacy of the various sections as representative for microscopic work. The following letters show the care taken by the committees in removing sections for this work:

Philadelphia, Pa., July 15, 1909.

Mr. H. A. Gardner, Director,
Paint Mfrs'. Association,
3500 Gray's Ferry Road, Phila., Pa.

Dear Sir:

An inspection was made July 13th at the wood panel fence, Atlantic City, by the writer, together with Messrs. George Butler, John A. Schaeffer and yourself.

Representative portions, each about 7 inches by 6 inches were marked out upon each of the white formulae panels of white pine, numbered, initialed, sawn from the panels and wrapped in tissue paper for microscopic tests, abrasion tests, etc., to be made by the Paint Mfrs'. Association. The portions are to be replaced upon the fence as soon as the tests are made.

Very truly yours,

(Signed) ROBERT JOB,
Chairman Sub-Committee of Committee E,
American Society for Testing Materials.

Philadelphia, July 30, 1909.

Mr. Henry A. Gardner, Director,
Scientific Section,
Paint Manufacturers' Assn. of U. S.,
Philadelphia, Pa.

Dear Sir:

Together with Robert Job, Chairman of the Sub-Committee of Committee E of the American Society for Testing Materials, Dr. Schaeffer and yourself, I made an inspection of the various panels on the Atlantic City test fence on July 13. Characteristic portions of each white pine panel, which could be counted upon as being normal portions for an inspection, were marked out, and the initials of the inspectors were placed upon the upper right-hand corner, while the numbers of the panels were placed in the lower left-hand corner. These portions, which were sufficiently large, were sawn from the panels and carefully enclosed in tissue paper. They were then turned over to Dr. Schaeffer for microscopic investigation and for other laboratory work, such as abrasion tests and tests for color, hardness, etc. These tests will probably be of great value in checking up the original report of the First Annual Inspection of the Atlantic City Test Fence, made in March.

Yours truly,

(Signed) GEORGE BUTLER,
Official Painter,
Master House Painters and Decorators of Philadelphia.

Pittsburg, Pa., July 31st, 1909.

Mr. Henry A. Gardner, Director,
Scientific Section,
Bureau of Promotion and Development,
Paint Manufacturers' Association of U. S.,
3500 Gray's Ferry Road,
Philadelphia, Pa.

Dear Sir:

On July 23rd, 1909, I inspected the Pittsburg test fence, and, with Dr. James, Chairman of the Carnegie Technical Schools' Test Fence Committee, selected a representative area on a white pine panel of each formula represented on the fence. The areas selected were carefully marked off, numbered and initialed, and then given to Dr. Schaeffer, to be studied for detailed condition, in the laboratory.

Very truly yours,

(Signed) ALFRED C. RAPP,
Chairman Test Fence Committee,
Pittsburg Branch, Master Painters' Association.

Pittsburg, Pa., July 31, 1909.

Henry A. Gardner, Director,
Scientific Section,
Paint Manufacturers' Association of U. S.,
Philadelphia, Pa.

Dear Sir:

Representative and thoroughly typical areas of the white pine panels representing the various formulas applied to the Pittsburg test fence were selected by me with Mr. Rapp, Chairman of the Test Fence Committee of the Master

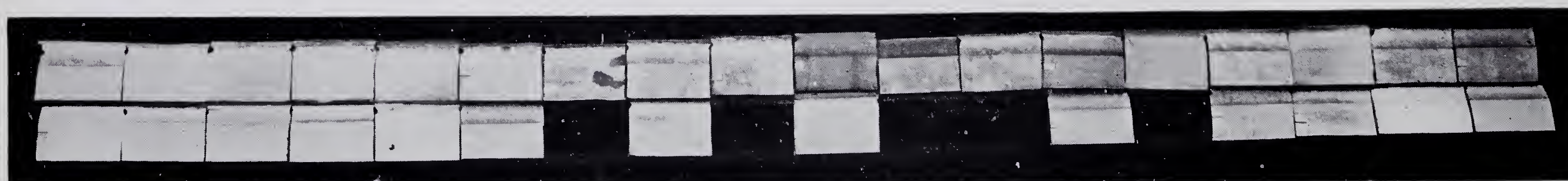
Painters, and these areas were carefully cut out, without disturbing the surface, and then carefully wrapped in tissue paper. They were then handed to Dr. Schaeffer, a member of the Test Fence Committee of the Carnegie Schools, who has taken them to the laboratories for a very close study, with the microscope and by other means, of the conditions which are generally observed when reporting upon the value of a paint, such as chalking, checking, color, gloss, etc. Careful laboratory work upon these samples will doubtless give an immense amount of interesting data which could not be obtained otherwise. Before removal from the fence each section was carefully numbered and initialed.

Yours truly,

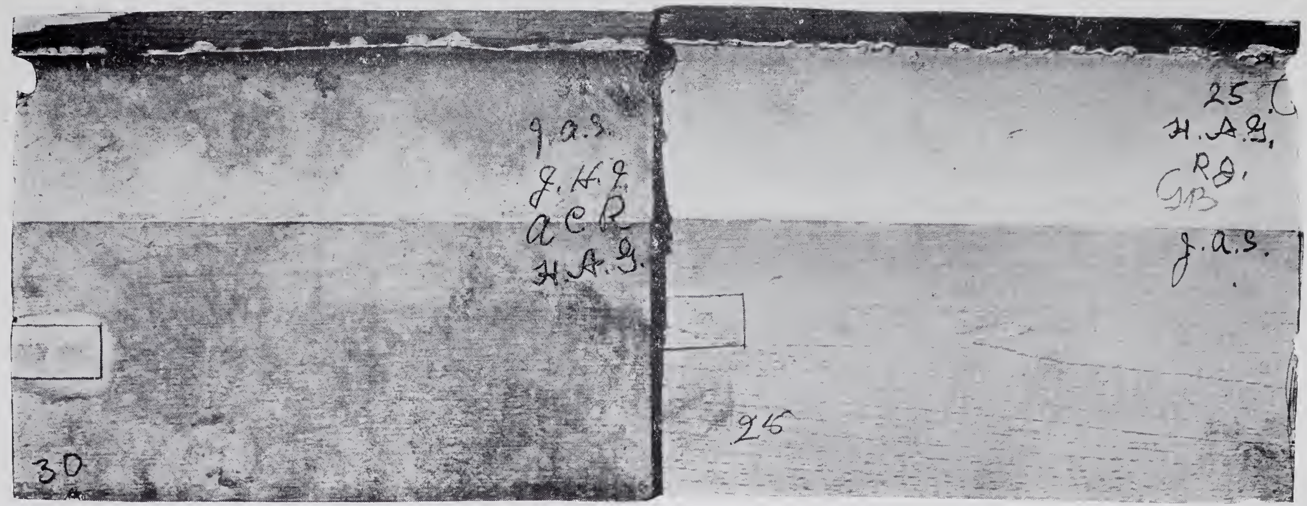
(Signed) J. H. JAMES,

Chairman, Carnegie Technical Schools' Fence Committee.

PLACEMENT OF PANELS ON ATLANTIC CITY FENCE



PLACEMENT OF PANELS ON PITTSBURG FENCE



CUT OF PITTSBURG AND ATLANTIC CITY MODEL PANELS

CHAPTER III

Checking and Cracking

What was termed "fine matt checking" at the First Annual Inspection was not visible at the time to certain members of the Inspection Committee, but it is an established fact that the checking was an existing condition, as the microscope has revealed. This checking has a very peculiar characteristic in that the lines are very narrow and hair-like, being somewhat interlaced and peculiarly forked. That this hair matt checking is a preliminary condition which afterward develops into matt checking and into marked or hard checking seems to be indicated.

It appears from an examination of the photomicrographs of the paint films that a paint coating resembles very much the surface of the earth and is subject to the same basic laws that have caused the various geodetic changes in the earth's crust. If one drives through the country and inspects a ledge of rock which appears through the ground by the roadside, certain definite stratification will be observed, and, in some instances, peculiar marks which identify the rocks with the period of their formation. Again, if one observes after a rain storm the clayey ground which has become smooth and hard, and then again observes the clay after the sun has beat upon it, it will be seen that the surface has begun to crack and fissure in a definite form, which resembles the cracking and fissuring of paint coatings after the sun has acted upon them. Erosion of rocks by constant rain storms, etc., seems to show the

same effect that a paint coating shows after it has been subjected to storms. Erosion of a paint coating is early evident when the paint is made of materials which act more or less on the oil, presenting a large surface of exposed pigment.

It will be noticed that the checking on most of the combination pigment paints was moderate, and in many cases was of a fine order. It has been observed that the percentage of zinc oxide in a paint is not always a criterion upon which future checking may be judged. Nor could it be said that the checking is dependent upon the percentage of basic carbonate-white lead added to the paint. However, it appears that scientific blending of the various pigments, with regard to their physical properties in oil, such as their strength and elastic limit, develops the greatest resistance to both cracking and checking. Elasticity is vital, but strength must be combined therewith in order to prevent disruptions of the paint coating. It appears that paint films made of certain inert pigments, when tested on the filmometer, were relatively high in strength, but relatively low in elasticity. Such pigments, when used in large percentage, form coatings which are hard and apt to crack. The use, however, of these pigments in moderate percentages seems very beneficial in overcoming the effect of using an excessive percentage of basic carbonate-white lead, or of zinc oxide.

The minimum checking was seen on some of the combination pigments.

The maximum checking was observed on the basic carbonate-white lead panels, in which case the size of the checks and lines was several times larger than those on the other panels, and in some cases craters were formed, of considerable magnitude.

On some of the basic carbonate-white leads the checking was of a very peculiar nature, consisting of very broad fissures in the paint coating, disclosing the wood surfaces beneath. The checking existing in basic carbonate-white lead was also distinct in its structure, being hexagonal in shape.

The most marked feature of the basic carbonate-white lead films was the extreme roughness of their surfaces, which under the microscope resembled in formation the picture presented by snowdrifts, the surfaces of which have been frozen and cracked. This roughness is most likely due to the bad chalking which had taken place and is not exhibited to any extent on the other panels.

Cracking is evidently a function of paint coatings, closely related to checking, yet distinct therefrom and dependent largely upon the nature of the pigments.

The checking of paints very high in silica resolved itself into fine hair-like lines which are generally lateral to each other, and indicate a cracked appearance.

The checking of paints containing very high percentages of barytes was also of a distinct nature, being generally forked in appearance and of no definite striation.

The panels painted with basic sulphate-white lead (sublimed white lead) showed complete absence of checking. This was also true of the panels painted with zinc lead. These are both fume products and are extremely fine in their physical size, which may account for this condition. Although zinc oxide is made in a similar manner, it gives a much harder paint coating than either of the afore-mentioned pigments, and presents a surface which develops considerable checking, generally of a medium order. The past theories regarding zinc oxide, in which it has been maintain-

ed that zinc oxide gives the maximum checking, are evidently incorrect, as the checking found on the zinc oxide panels was not as marked or deep as the checking on the basic carbonate-white lead panels; in fact, the checking might be more in the line of a cracking, possibly due to the somewhat brittle nature of the coating composed of straight zinc.

At Atlantic City the panels were all clean and free from dirt, presenting continuous exposure of the films and thus maintaining conditions for active checking. At Pittsburg, soon after the panels began to chalk, the large amount of dust and black soot in the atmosphere completely covered the panels with a very thick, resistant coating of carbon, which acted as a seal or protective coating, preventing the disintegration of the formulas to a certain extent. This coating was extremely hard to remove, and photomicrographs before and after removal of this coating, by rubbing with a damp cloth, fail to reveal any marked checking of any of the formulas except those made of strictly pure basic carbonate-white lead. The checking, even on these, is not nearly as marked as at Atlantic City. It is presumed that after the chalking had taken place and the chalked pigment had been washed from the panels the gradually increasing coat of carbon and lead sulfide had protected the panels from checking, or possibly the atmosphere of Pittsburg, which in other respects had deteriorated the panels to a greater extent than at Atlantic City, did not have the extreme action in causing checking that the Atlantic City atmosphere seemed to show. We have published herewith photographs of several of the panels on the Pittsburg fence before and after the removal of the coating of carbon or soot, and it will be observed that very little checking has taken place. The coating on the white lead boards was somewhat darker in nature than the

others, showing that the formation was possibly due to sulphide of lead formed from the sulphur gases of the district immediate to Pittsburg.

The photomicrographs of each of the Atlantic City formulas gives in detail the condition of the checking which has taken place. All of these photomicrographs were taken in the same manner and with the same magnification—by illuminating the field with the rays of light reflected from a glass in front of an arc lamp. The formula of the paint coating represented, and the panel number, are given opposite each photomicrograph.

It appears that very fine grinding of materials, chosen for their characteristic fineness, with the absence of any unfavorable physical condition or chemical sensitiveness, are important factors in the making of a paint to resist cracking or checking. The purity of the essential materials, as well as the scientific compounding of these materials, with due regard to the law of minimum voids, are great factors which enhance the qualities of paints, greater, perhaps, than the variation of percentages of the various pigments which go to make up a paint.

CHAPTER IV

Photomicrographs

The photomicrographs which are herewith given were made in the following manner:

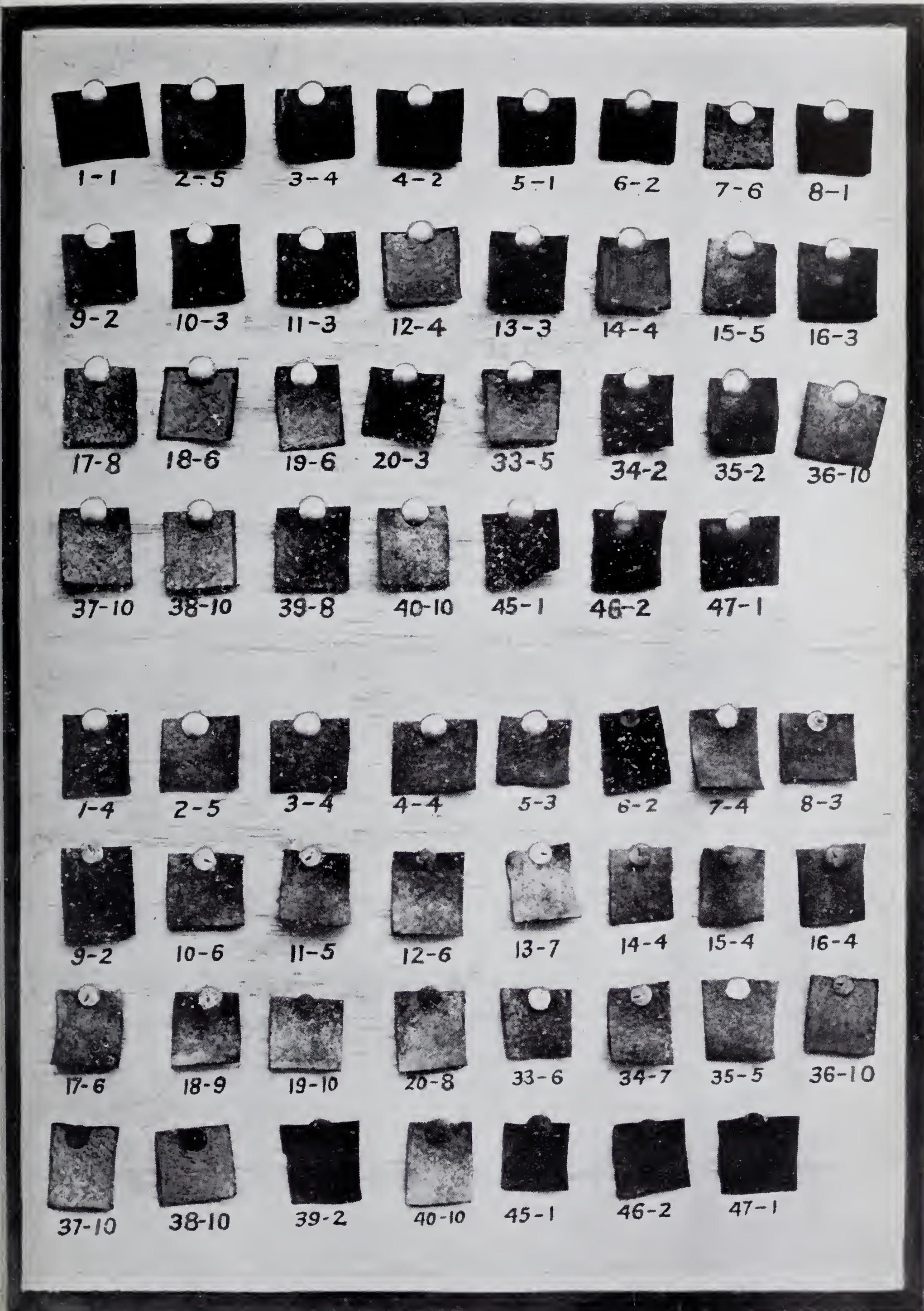
A part of a panel was placed upon the stage of the microscope and held firmly in place with clips. By varying the adjustment and carefully running over the field the condition of the surface was readily given, using the same eye-piece and objective throughout the tests, and obtaining a magnification of thirty-three. Great care was exercised to secure an average field showing the general and typical appearance of every panel. Little difficulty was experienced in so doing, as the laboratory panels were very representative surfaces of the large panels on the fence. The instrument was then inclined horizontally and the eye-piece was fitted into the camera nose. In the back of the bellows of the camera was placed the ground glass for focusing. To secure illumination the light from an electric arc lamp was reflected from a mirror direct onto the painted surface of the panel, which in turn was reflected through the camera onto the ground glass. The plate-holder was then put in position and six-second exposures were made, afterward developing and printing.

CHAPTER V

Chalking

The chalking of the various formulas was gauged by using the method used originally at Atlantic City at the First Annual Inspection. When used in the laboratory, small strips of black felt, about one inch square, were firmly attached to a block of wood and by a clamp having the same pressure in each case, the wood with its surface of black felt was fixed to the panel. This apparatus, which resembles a blackboard eraser, is firmly drawn across the panel in one direction for a certain definite distance, during which time it gathers all the chalked surface presented by the painted wood. Upon detaching the apparatus from the panel it is observed that the black cloth becomes whitened to an extent proportionate to the chalking that has taken place on the given area.

After each one of the panels had been treated in the same manner by the same operator, the black cloths were assembled on one large board and photographed. A definite standard of chalking was made up, and the operator was enabled to put down opposite the report on each panel the degree of chalking which had taken place, No. 1 representing the least amount and No. 10 the greatest amount of chalking.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37-10 38-10 39-8 40-10 45-1 46-2 47-1
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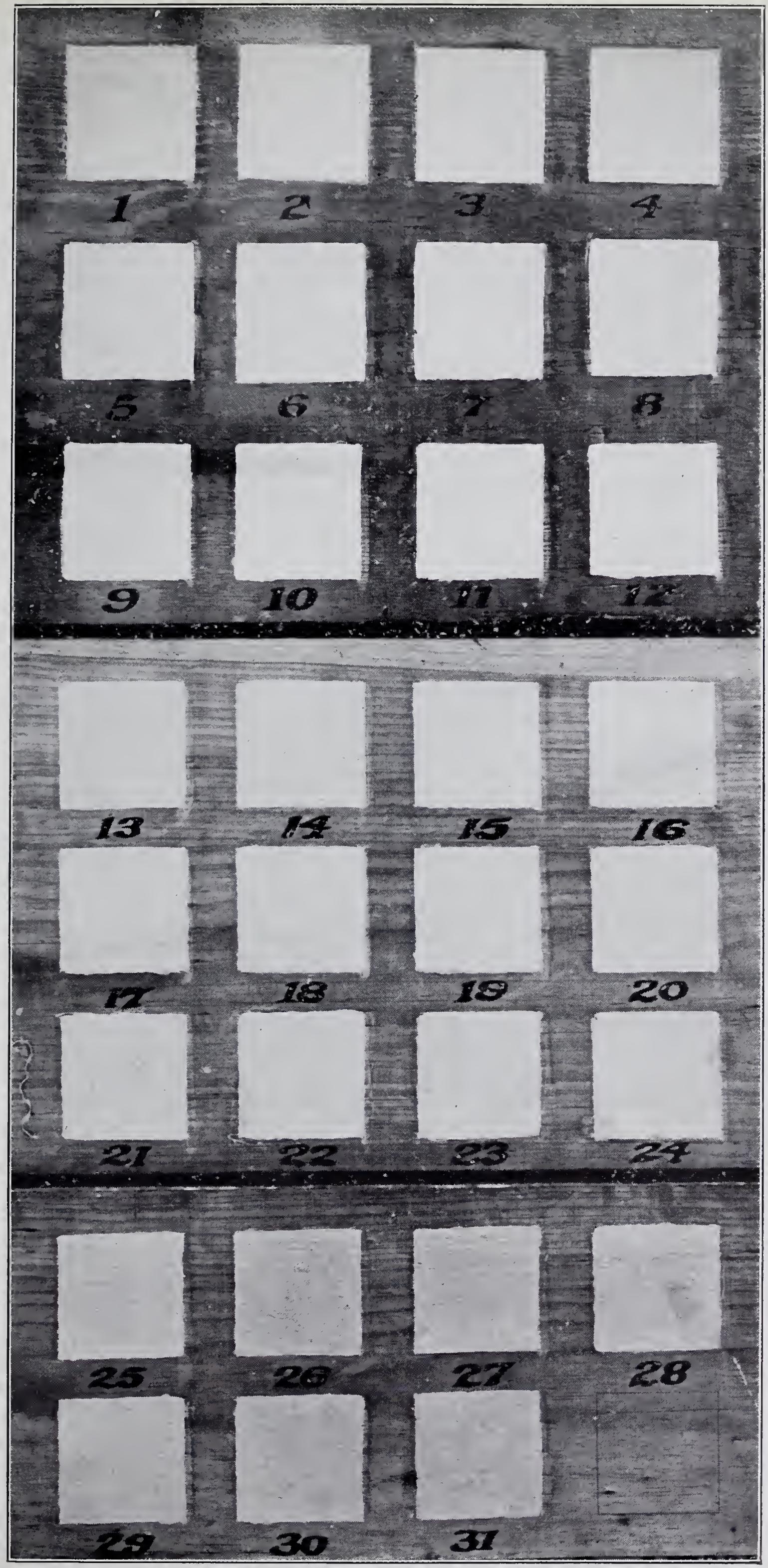
9-2 10-6 11-5 12-6 13-7 14-4 15-4 16-4
17-6 18-9 19-10 20-8 33-6 34-7 35-5 36-10
37-10 38-10 39-2 40-10 45-1 46-2 47-1

CHAPTER VI

Whiteness

It was a very simple matter to gauge the whiteness of the various panels, by comparing them with a set of standard boards painted white. Florence Brand, New Jersey, zinc oxide was used as the standard and termed "No. 1." In making "No. 2" standard to the zinc oxide was added .01% of lamp black. By adding .02% of lamp black to the zinc, standard "No. 3" was obtained, and so on, increasing the amount of lamp black in each case by .01%. These standards were painted on white pine boards, three coats being applied. These standards were run up to "No. 30," and the various panels on the different fences compared with them. The degrees of whiteness are recorded in progressive numbers, No. 1 being the standard for whiteness and No. 30 the darkest. The Atlantic City panels ranged from 3 to 8 in the scale of whiteness, while the Pittsburg panels required the use of the entire range of the colors.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CHAPTER VII

Abrasion Resist

The apparatus for determining the amount of abrasion resist which a paint possesses was suggested by Mr. Perry and built by the Section. It consists of a glass tube about six feet long, having an internal bore of ⅞-inch. This was supported in an upright position over a dish which held the panel to be tested, at an angle of 45 degrees. The abrasive material consisted of No. 50 emery, which was dropped into the tube through a funnel having a bore of 5 m. m. When the emery reached the bottom of the long tube it scattered itself so as to strike a surface on the panel about an inch in diameter. The emery was constantly poured in until the paint coating had worn away, showing the bare wood. The weight in pounds of emery powder required to show the disruption of the coating is recorded and reported as the measure of the "abrasion resist." The panel showing the greatest weight of emery to cause abrasion is evidently the most resistant to abrasion. Paint is often subjected to serious abrasion, through the blowing of sand, especially at the seashore, and to be resistant to this must contain, evidently, a considerable proportion of pigments especially resistant to abrasion. Silica, zinc oxide, asbestine, or perhaps barytes seem suited to resist abrasion to a great degree.

CHAPTER VIII

Hardness

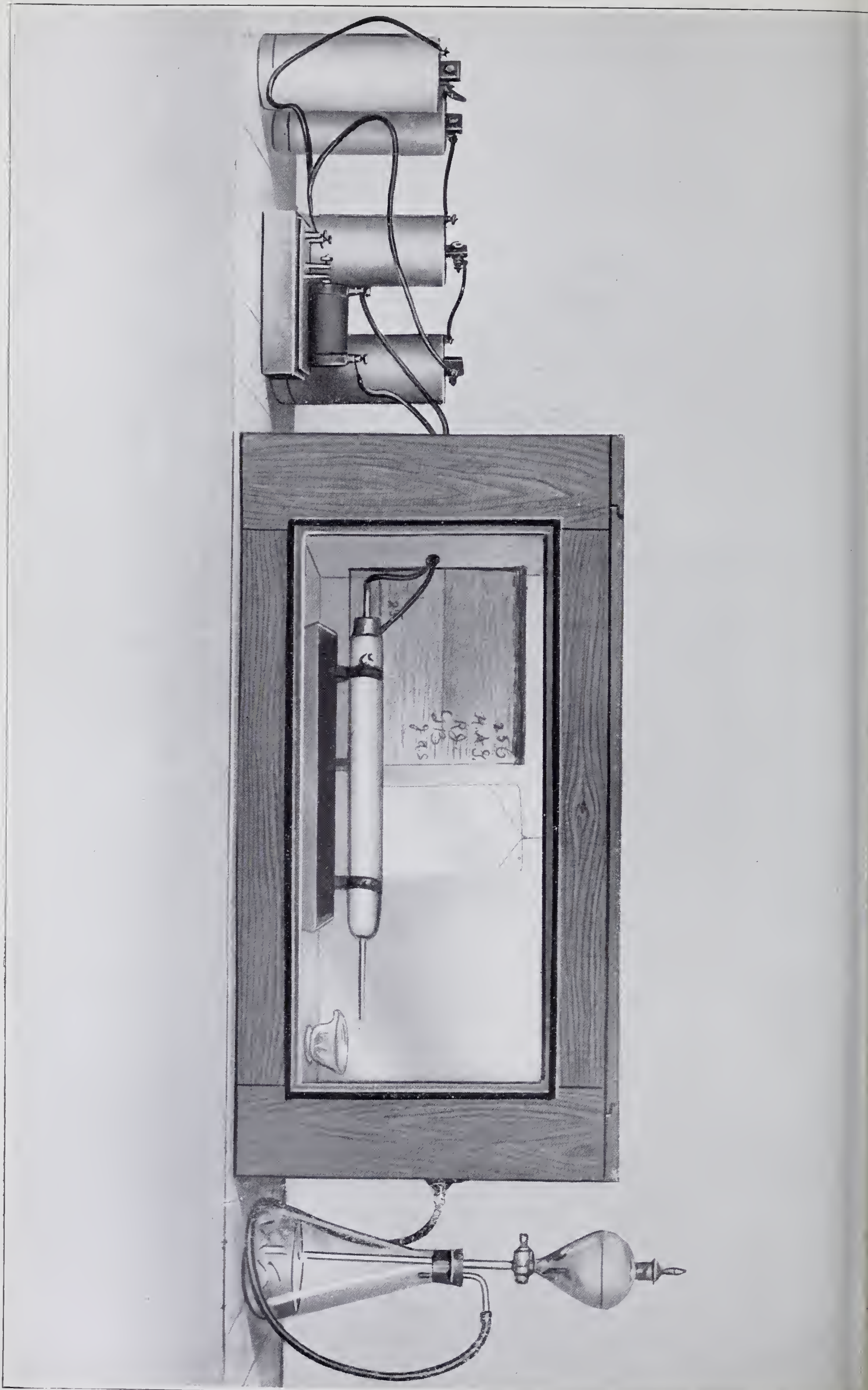
Several methods of determining the hardness of the painted panels were tried out, including the method using the apparatus designed by Baily & Laurie. It was found, however, that the most satisfactory was the use of a set of minerals which run from 1 to 10 in their degree of hardness. Each panel was rubbed with these minerals in their consecutive order until the mineral was determined with which a scratch was apparent and the number of the mineral which caused the scratch was given as the number of hardness of the panel.

The results obtained by this method would allow the grouping of the panels into three sets termed Soft, Medium Hard, and Hard, but it has been considered advisable to wait until greater refinement and further confirmation is obtained before printing results.

CHAPTER IX

Accelerated Testing of Painted Surfaces With New Apparatus

It was thought that a test would be of value whereby the panels could be subjected to an artificial atmosphere containing carbonic acid gas, ammonia, etc., in such quantity and variety as would duplicate in their relative amounts their presence in the atmosphere peculiar to various localities, and which might in a very short time give the results which were obtained in the field during a longer period. An apparatus was designed for the testing out of various steels, to show their resistance to corrosion, and the testing of various painted steels to show the value of protective coatings, and used in this test. (See illustration.) It consists of a large box, with glass sides and top. In the top of the box are a row of girders upon which are hung small hooks to suspend the panels of any nature, whether steel or wood. On the side of the box is an entrance through which a constant current of carbon dioxide is passed. In the bottom of the box is a long tray containing water, which keeps the atmosphere in the box constantly humid. The temperature is maintained at 70 degrees constantly, and sulphurous acid may be generated within by allowing a small portion of sodium bisulphite to be acted upon by sulphuric acid, contained in a bottle in a corner of the box. Ammonia may be developed by placing in another corner of the box a very dilute solution of ammonia water which at the 70-degree temperature evaporates and permeates the atmosphere. Ozone may be developed



by a small make-and-break circuit on a Ruhmkorff's coil connected up to some dry cells and placed together with a tube condenser lined with tin foil.

It is possible with the aid of this apparatus to obtain the condition existing in sea air by the passage of chlorine in the box, and it is also possible to approximate the atmosphere of Pittsburg by the passage into the box of those particular gases which are typical of that city.

H. A. GARDNER,
Director.

CHAPTER X

Report of Dr. John A. Schaeffer *

August 20, 1909.

MR. HENRY A. GARDNER, Director,
Scientific Section, Bureau of Promotion and Development, Paint Manufacturers' Association of U. S.,
3500 Gray's Ferry Road, Phila.

Dear Sir:—

I herewith submit to you the results of the laboratory investigations conducted on the panels of the Atlantic City and Pittsburg test fences.

The work was carried out on sections of the panels seven by six inches in size. These sections were carefully selected and marked out on the fence panels by representative committees. They were then sawed out, immediately wrapped in tissue paper to prevent damaging the paint coatings and were then handed to me for laboratory investigation.

The sections thus obtained were truly characteristic areas of the coating covering the entire panel, and gave a true expression of the way in which each formula withstood disintegration after a period of a little over a year in length.

The problem was attacked in several ways, so that a definite idea of the character of the paint film could be obtained. It embraces the following points:

(1) A microscopic study of the paint film.
(2) Color.
(3) Chalking.

* Instructor in Chemical Practice, Carnegie Technical Schools, Pittsburg, Pa.

(4) Abrasion resistance.
(5) The effect of the accelerated test.
(6) Hardness.

In placing the Atlantic City sections and the Pittsburg sections together on a model test fence erected in the laboratory there was a marked difference in the appearance of the breakdown of the two sets of panels. This difference was undoubtedly due to the atmospheric conditions prevailing at either place. One would be led to suppose that a paint film, which was exposed to an atmosphere such as is found in the Pittsburg district, would show deterioration more rapidly than one exposed to the air such as is found at Atlantic City. In all the tests and experiments made, the Atlantic City panels, however, appeared to be broken down to a much greater extent than the Pittsburg panels. It is true that the Pittsburg panels had darkened greatly and gave a poor appearance, owing to the impurities in the atmosphere, but just these impurities settling on the paint film acted as a preservative coating for the film beneath, and prevented disintegration from proceeding. In some cases the paint coatings were changed chemically. Aggregations of lead sulfide were sometimes apparent when the high power hand glass was placed on the panels. This was the finding of the committee present.

In making the standards for whiteness, zinc oxide and lampblack of the following composition were used:

Zinc Oxide	45.12%
Linseed Oil	54.88%

The analysis of the lampblack is as follows:

Pigment	26%		
Vehicle	74%	Linseed Oil	92%
		Japan Drier	8%

A micrographic study of paint films, when exposed to

the atmosphere for any length of time, offers one of the best methods of studying such coatings. The marked difference between the sections obtained from the Pittsburg panels and those obtained from the Atlantic City panels is, however, particularly noteworthy.

The Atlantic City paint films show that checking had proceeded to a marked degree. This checking is characteristic in many cases, as is shown in the tri-angular checks of a pure zinc oxide film, and the broad hexagonal cracks of a basic carbonate-white lead film. These characteristic checks appear in many of the composite paints. The sublimed white lead film gives no evidences of checking, due to the finely divided particles of the pigment. In the case of the Pittsburg sections, several photographs were made of the film before the removal of the black coating, due to the impurities of the atmosphere, by washing. A photograph was made of each one of the formulae applied to this fence, the outer black surface being removed by gentle washing with a damp cloth. These photographs show that the Pittsburg panels have, only in a very few cases, begun to check. In the other cases it is seen that the smooth surface still exists. In some instances, however, small indentations appear on the film, due to a slight penetration of coal dust or lead sulfide aggregations. In the case of the basic carbonate-white lead panels in the Pittsburg district it is seen that checking has begun to a slight extent, and this checking can even be seen through the coating of impurities which have settled on the outer surface. These give the most marked checking of the Pittsburg panels.

The abrasion resist test is particularly valuable in showing the relation existing between a paint film which has become covered with a protective coating due to the impurities in the air, and a paint film which has had to resist the

agencies of the atmosphere strictly on its own merits, or between a film that is fairly intact and one that has broken down physically or chemically.

The abrasion resistance of a paint film is largely dependent upon the chalking and checking which has taken place, except in such instances where the coating has become brittle, thus cracking and scaling and losing its power of acting as a true coating.

In practically every case the deterioration of the Atlantic City panels had proceeded more rapidly than the Pittsburg panels, and when not influenced by excessive chalking and checking, gave a moderate difference in the resistance to the abrasion test. By a comparative study of the results obtained in the two cases, indications can be obtained regarding the resistance offered by the respective formulae.

THE EFFECT OF THE ACCELERATED TEST.

The accelerated test box which was devised is a method for bringing about the conditions confronting a paint film, in an accelerated way. Some work was done on the paint films by this test, but it has not as yet proceeded sufficiently far to permit of the publication of the results. Whether the method would duplicate in an exact way the action of the elements on a paint film, cannot as yet be definitely stated, but there is every reason to believe that the accelerated box is a step in the right direction, toward the solving of this problem.

Respectfully submitted,

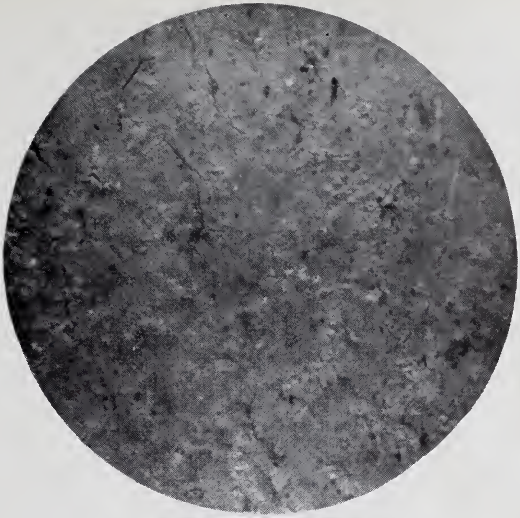
(Signed) DR. JOHN A. SCHAEFFER,
Instructor in Chemical Practice,
Carnegie Technical Schools,
Pittsburg, Pa.

Atlantic City Test Fence

Formula No. 1

	M. F.	C. A.*
Basic Carbonate— White Lead	30%	34%
Zinc Oxide	70%	66%

Checking: Paint film almost intact. Note the tri-angular checking characteristic of zinc oxide in the early stages of formation.
Chalking: 1
Color: 4
Abrasion Resist: 24 lbs. emery.



Formula No. 2

	M. F.	C. A.
Basic Carbonate— White Lead	50%	50%
Zinc Oxide	50%	50%

Checking: Combination cracking of two intimately mixed and evenly proportioned pigments.
Chalking: 5
Color: 5
Abrasion Resist: 20 lbs. emery.

Formula No. 3

	M. F.	C. A.
Basic Carbonate— White Lead	20%	16%
Basic Sulphate— White Lead	20%	30%
Zinc Oxide	50%	44%
Calcium Carbonate	10%	10%

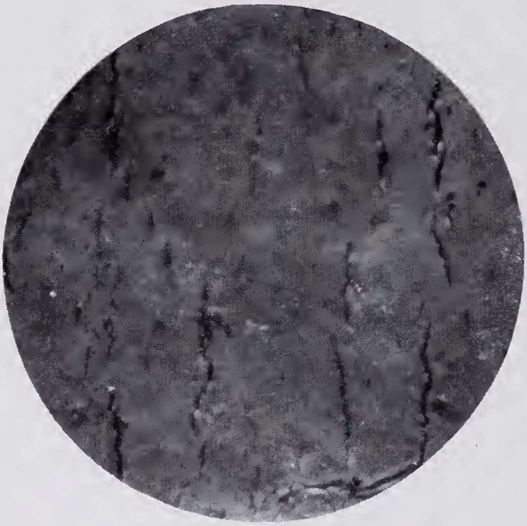
Checking: Usual irregular checking of a composite paint.
Chalking: 4
Color: 3
Abrasion Resist: 36 lbs. emery.

***M. F.—Manufacturers Formula**
***C. A.—Chemists Analysis**

Formula No. 4

	M. F.	C. A.
Basic Carbonate—White Lead	48.5%	49%
Zinc Oxide	48.5%	48%
Calcium Carbonate	3.0%	3%

Checking: Cracks perceptible.
Chalking: 2
Color: 4
Abrasion Resist: 31 lbs. emery.



Formula No. 5

	M. F.	C. A.
Basic Carbonate—White Lead	22%	21%
Zinc Oxide	50%	49%
Calcium Carbonate	2%	4%
Aluminum and Magnesium Silicates	26%	26%

Checking: Breakdown advancing slightly along the grain of the wood.
Chalking: 1
Color: 4
Abrasion Resist: 31 lbs. emery.

Formula No. 6

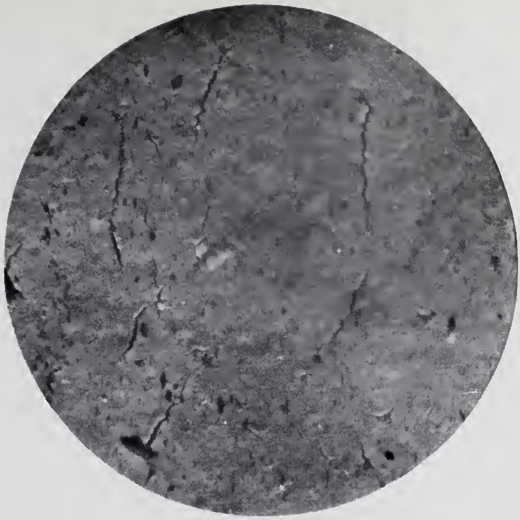
	M. F.	C. A.
Zinc Oxide	64%	63%
Barytes	36%	37%

Checking: Numerous, short, thin, and irregular surface breaks.
Chalking: 2
Color: 5
Abrasion Resist: 29 lbs. emery.

Formula No. 7

	M. F.	C. A.
Basic Carbonate—White Lead	37%	45%
Zinc Oxide	63%	55%

Checking: Closely follows the lines of cracking displayed in No. 4.
Chalking: 6
Color: 4
Abrasion Resist: 18 lbs. emery.



Formula No. 8

	M. F.	C. A.*
Basic Carbonate—White Lead	38%	38%
Zinc Oxide	48%	48%
Silica	14%	14%

Checking: Outer surface only slightly serrated.
Chalking: 1
Color: 4
Abrasion Resist: 36 lbs. emery

Formula No. 9

	M. F.	C. A.
Zinc Oxide	73%	75%
Silica	25%	22%
Calcium Carbonate	2%	3%

Checking: Combination, broad, angular checking, displaying characteristics both of zinc oxide and silica.
Chalking: 2
Color. 6
Abrasion Resist: 5lbs. emery. Surface brittle. Not like Pittsburg. Low abrasion resist due to excessive cracking.

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* Tentative

Formula No. 10

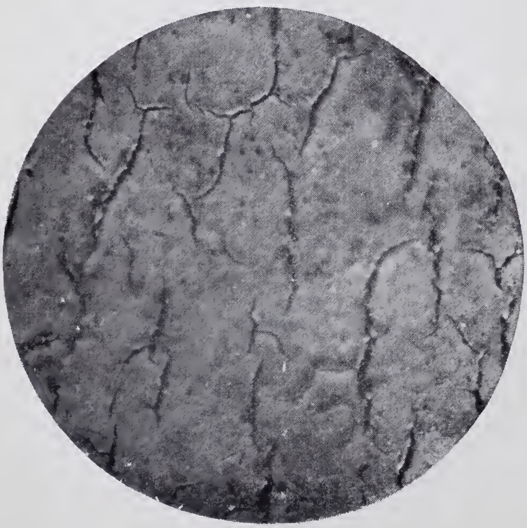
	M. F.	C. A.
Basic Carbonate—White Lead	44%	43%
Zinc Oxide	46%	43%
Calcium Carbonate	5%	8%
Magnesium Silicate	5%	6%

Checking: Cracking shallow and thread-like, following the grain of the wood.
Chalking: 3
Color: 4
Abrasion Resist: 21 lbs. emery.

Formula No. 11

	M. F.	C. A.
Basic Carbonate—White Lead	50%	49%
Zinc Oxide	50%	51%

Checking: Irregular, short and fairly deep.
Chalking: 3
Color: 4
Abrasion Resist: 23 lbs. emery.



Formula No. 12

	M. F.	C. A.
Basic Carbonate—White Lead	60%	61%
Zinc Oxide	34%	34%
Inert Pigment	6%	5%

Checking: Medium and of a general nature, but superficial.
Chalking: 4
Color: 5
Abrasion Resist: 24½ lbs. emery No. 50.

Formula No. 13

	M. F.	C. A.
Basic Sulphate—White Lead	60%	57%
Zinc Oxide	27%	31%
Magnesium Silicate	10%	8%
Calcium Carbonate	3%	4%

Checking: Threads advancing along the grain of the wood.
Chalking: 3
Color: 4
Abrasion Resist: 17½ lbs. emery.

Formula No. 14

	M. F.	C. A.
Basic Carbonate—White Lead	25%	25%
Basic Sulphate—White Lead	20%	16%
Zinc Oxide	25%	27%
Calcium Sulphate	25%	28%
Calcium Carbonate	5%	4%

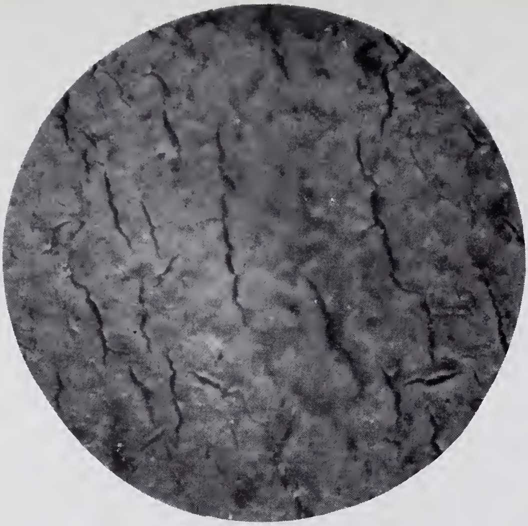
Checking: Peculiar erosion-like effect spreading over the entire surface.
Chalking: 4
Color: 5
Abrasion Resist: 14 lbs. emery.

Formula No. 15

	M. F.	C. A.*
Zinc Lead White	30%	30%
Zinc Oxide	40%	40%
Basic Carbonate—White Lead	20%	20%
Calcium Carbonate	10%	10%

Checking: Following the lines and general appearance of No. 20, though slightly more advanced.
Chalking: 5
Color: 5
Abrasion Resist: 8 lbs. emery.

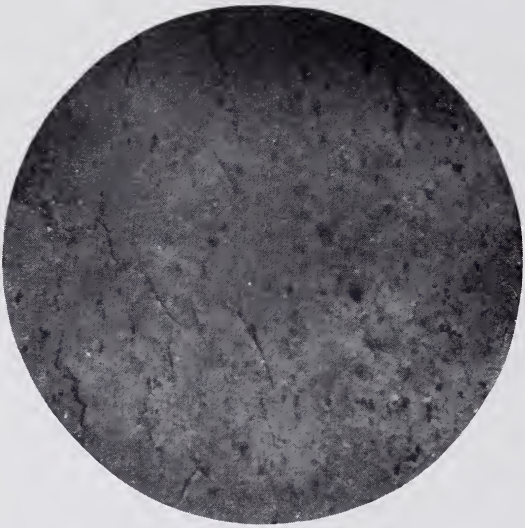
*** Tentative**



Formula No. 16

	M. F.	C. A.
Basic Carbonate—White Lead	33%	34%
Zinc Oxide	33%	35%
Barytes	34%	31%

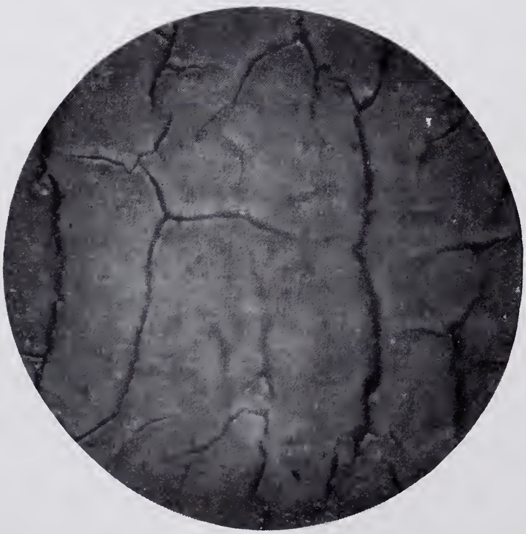
Checking: Checking follows lines of No. 6.
Chalking: 3
Color: 8
Abrasion Resist: 16 lbs. emery.



Formula No. 17

	M. F.	C. A.
Barytes	13%	13%
Blanc Fixe	4%	4%
Asbestine	3%	3%
Zinc Oxide	40%	43%
Basic Carbonate—White Lead	40%	37%

Checking: Slight cracks of an eruptive nature; tends to follow grain of wood.
Chalking: 8
Color: 5
Abrasion Resist: 13 lbs. emery.



Formula No. 18

	M. F.	C. A.
Basic Carbonate—White Lead (in oil)	75%	79%
Zinc Oxide (in oil)	25%	21%

Checking: Somewhat widely separated fissures of slightly more than mean depth.
Chalking: 6
Color: 4
Abrasion Resist; 17 lbs. emery.

Formula No. 19

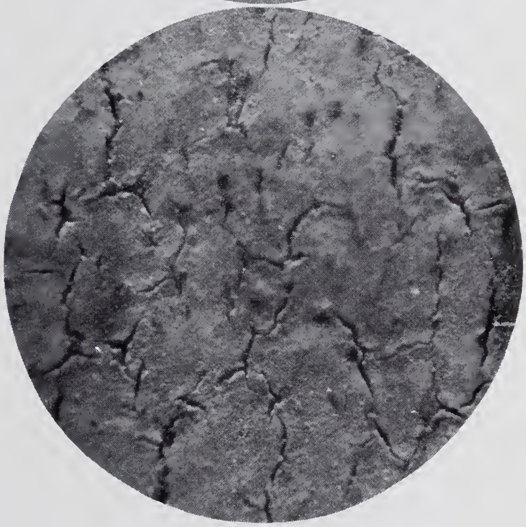
	M. F.	C. A.
Basic Sulphate—White Lead (in oil)	75%	66%
Zinc Oxide (in oil)	25%	34%

Checking: Numerous and deep three-cornered cracks gradually uniting. A domination of the zinc oxide characteristics over that of the basic sulphate.
Chalking: 6
Color: 4
Abrasion Resist: 14 lbs. emery.

Formula No. 20

	M. F.	C. A.
Basic Carbonte—White Lead	67%	66%
Zinc Oxide	19.5%	19%
Asbestine	3.5%	5%
Calcium Carbonate	10.0%	10%

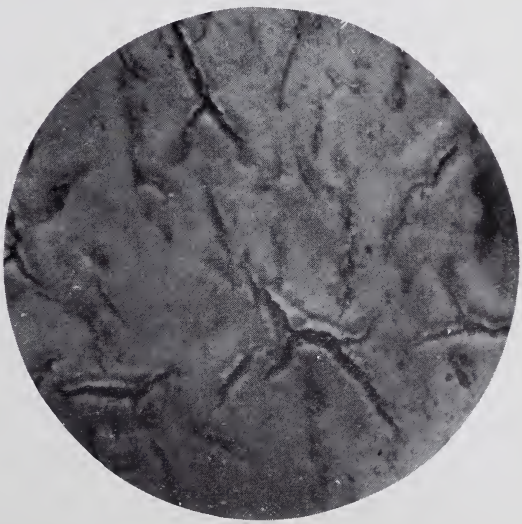
Checking: Thin, irregular ununited threads, showing the value of reinforcing pigments.
Chalking: 3
Color: 5
Abrasion Resist: 20 lbs. emery.



Formula No. 33

	M. F.	C. A.
Zinc Oxide	30%	33%
Special Silica	30%	30%
Basic Carbonate—White Lead	15%	17%
Basic Sulphate—White Lead	25%	20%

Checking: Deep. broad, hexagonal checks Do not extend to the wood, but simply give a veined appearance· A tough under surface exists.
Chalking: 5
Color: 6
Abrasion Resist: 39 lbs. emery.



Formula No. 34

	M. F.	C. A.
Basic Carbonate—White Lead	38.95%	36%
Basic Sulphate—White Lead	4.81%	7%
Zinc Oxide	33.58%	36%
Calcium Carbonate	19.48%	18%
Barytes and Silica	3.18%	3%

Checking: Showing the surface effect due to initial break-down.
Chalking: 2
Color: 5
Abrasion Resist: 21 lbs., emery.

Formula No. 35

	M. F.	C. A.
Basic Carbonate—White Lead	37.51%	38%
Basic Sulphate—White Lead	7.84%	5%
Zinc Oxide	25.87%	27%
Calcium Carbonate	20.36%	20%
Barytes and Silica	8.42%	10%

Checking: Triangular checking of zinc oxide: checks not united.
Chalking: 2
Color: 5
Abrasion Resist: 26 lbs. emery.

Formula No. 36

	M. F.	C. A.
Basic Carbonate—White Lead Type "B"	100%	100%

Checking: General characteristic cracking of white lead with very rough surface.
Chalking: 10
Color: 6
Abrasion Resist: 8 lbs. emery.

Formula No. 37

M. F. C. A.

Strictly Pure Basic Carbonate — White Lead Type "C" 100% 100%

Checking: Network of deep and irregular fissures characteristic of white lead.

Chalking: 10

Color: 5

Abrasion Resist: 7½ lbs. emery.

Formula No. 38

M. F. C. A.

Strictly Pure Basic Carbonate — White Lead Type "A" 100% 100%

Checking: General network-like cracking highly pronounced as in Formula No. 37.

Chalking: 10

Color: 4

Abrasion Resist: 8 lbs. emery.

Formula No. 39

M. F. C. A.

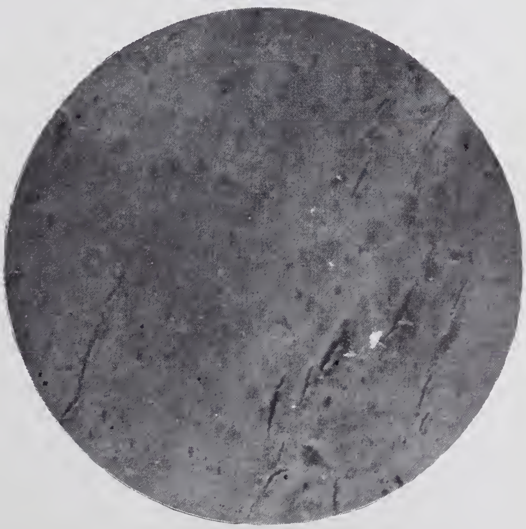
Zinc Lead 100 100%

Checking: Traces of fine thread-like cracking, almost negligible.

Chalking: 8

Color: 7

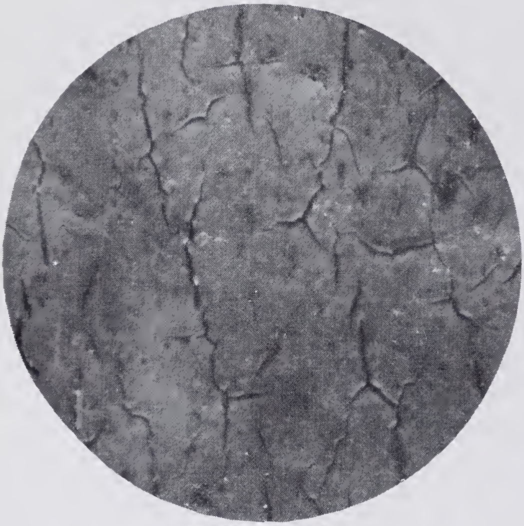
Abrasion Resist: 12 lbs. emery.



Formula No. 40

	M. F.	C. A.
Basic Sulphate—White Lead	100%	100%

Checking: Smooth, even surface, free from checking.
Chalking: 10
Color: 4
Abrasion Resist: 7½ lbs. emery.



Formula No. 45

	M. F.	C. A.
Zinc Oxide	90%	91%
Calcium Carbonate	10%	9%

Checking: Triangular cracking of zinc oxide plainly evident, though not so pronounced as in pure zinc oxide, due to reinforcing material.
Chalking: 1
Color: 5
Abrasion Resist: 24 lbs. emery.

Formula No. 46

	M. F.	C. A.
Zinc Oxide	61%	63%
Barytes	39%	37%

Checking: Dense and diverse fissures of mean depth.
Chalking: 2
Color: 8
Abrasion Resist: 33 lbs. emery.

Formula No. 47

	M. F.	C. A.
Zinc Oxide	100%	100%

Ground in Special Boiled Oil

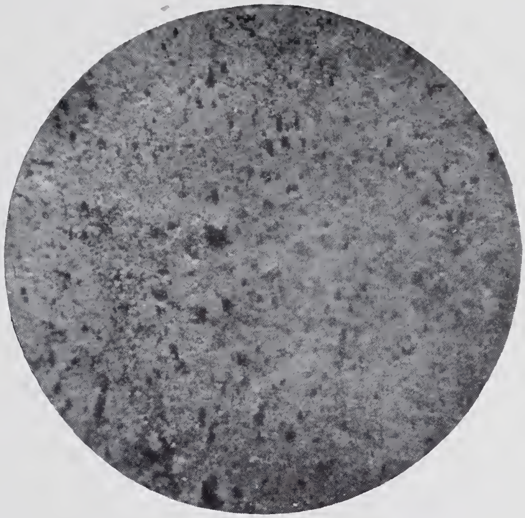
Checking: Usual triangular cracking of semi-depth.

Chalking: 1

Color: 4

Abrasion Resist: 38 lbs. emery.

Pittsburg Test Fence



Combination Formula
Before Washing

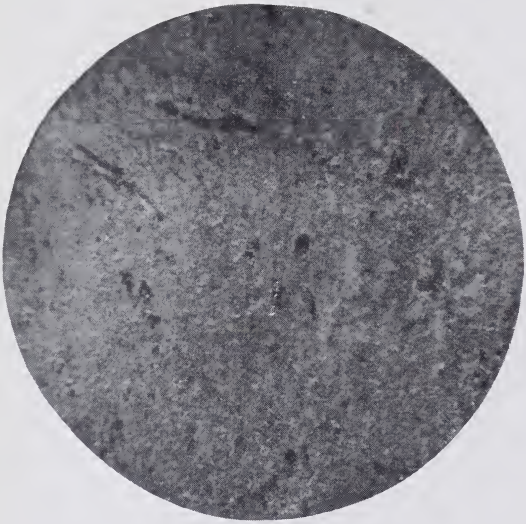
Mottled surface due to external coating of impurities.

After Washing
Formula No. 1—Panel No. 2.

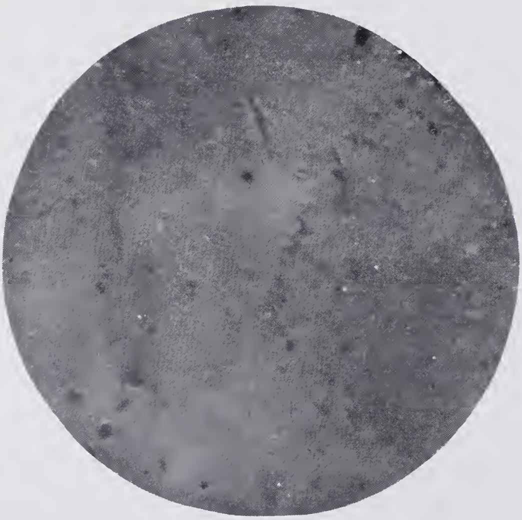
	M. F.	C. A.*
Basic Carbonate— White Lead	30%	34%
Zinc Oxide	70%	66%

Checking: Smooth surface.
Chalking: 4
Color: 20
Abrasion Resist: 28 lbs. emery.

***M. F.—Manufacturers Formula**
***C. A.—Chemists Analysis**



Before Washing



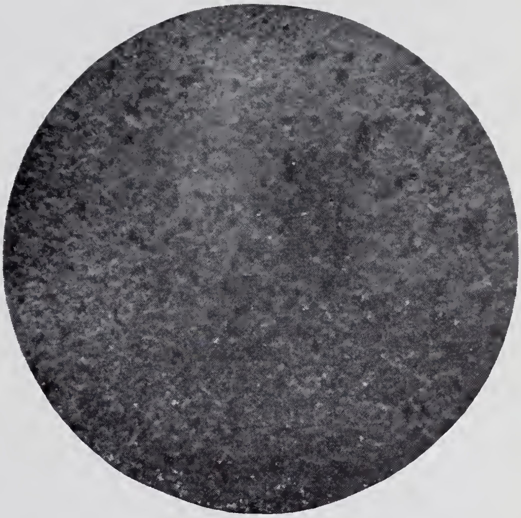
After Washing

Formula No. 2—Panel No. 4.

	M. F.	C. A.
Basic Carbonate—White Lead	50%	51%
Zinc Oxide	50%	49%

Checking: Very slight evidence of checking.
Chalking: 5
Color: 21
Abrasion Resist: 25 lbs. emery.

Before Washing



After Washirg

Formula No. 3—Panel No. 6.

	M. F.	C. A.
Basic Carbonate—White Lead	20%	24%
Basic Sulphate—White Lead	20%	19%
Zinc Oxide	50%	46%
Calcium Carborate	10%	11%

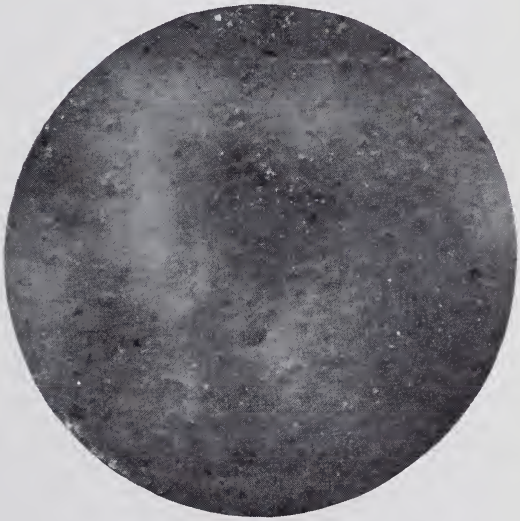
Checking: Scars showing where impurities had settled.

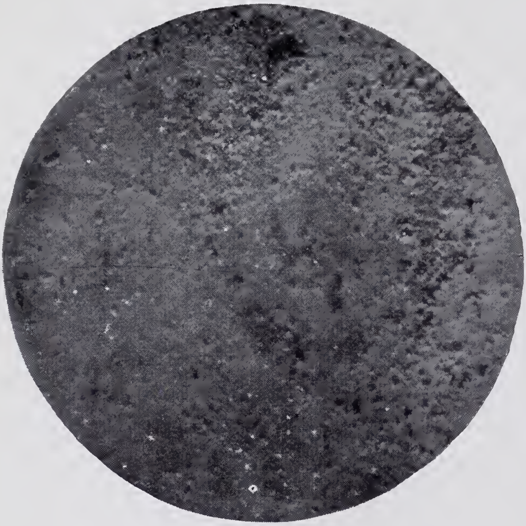
Checking:

Chalking: 4

Color: 8

Abrasion Resist: 42 lbs. emery.





Before Washing

After Washing

Formula No. 4—Panel 8

	M. F.	C. A.
Basic Carbonate— White Lead	48.5%	49%
Zinc Oxide	48.5%	48%
Calcium Carbonate	3.0%	3%

Checking: Slight evidence of checking along grain of wood.

Chalking: 4

Color: 11

Abrasion Resist: 36 lbs. emery.

After Washing

Formula No. 5—Panel No. 10

	M. F.	C. A.
Basic Carbonate—White Lead	22%	21%
Zinc Oxide	50%	52%
Calcium Carbonate	2%	2%
Aluminum & Magnesium Silicates	26%	25%

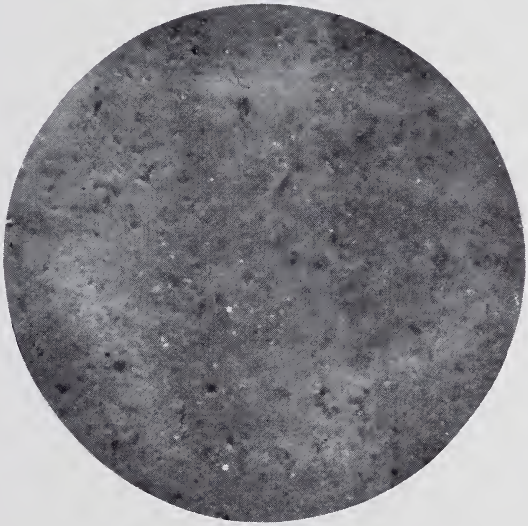
Checking: Smooth surface.
Chalking: 3
Color: 13
Abrasion Resist: 25 lbs. emery.

After Washing

Formula No. 6—Panel No. 12

	M F.	C. A.
Zinc Oxide	64%	63%
Barytes	36%	37%

Checking: Small foreign particles still adhering.
Chalking: 2
Color: 21
Abrasion Resist: 31 lbs. emery.

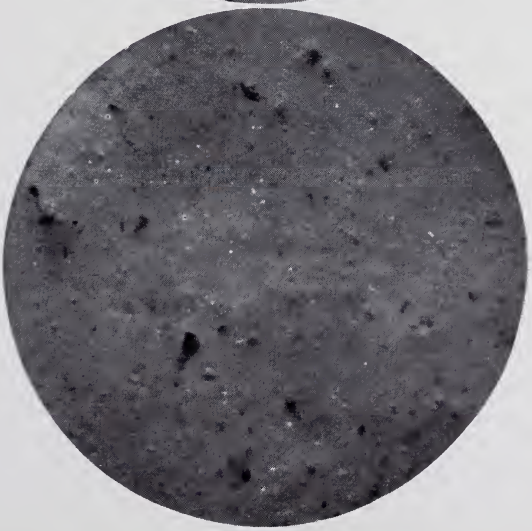


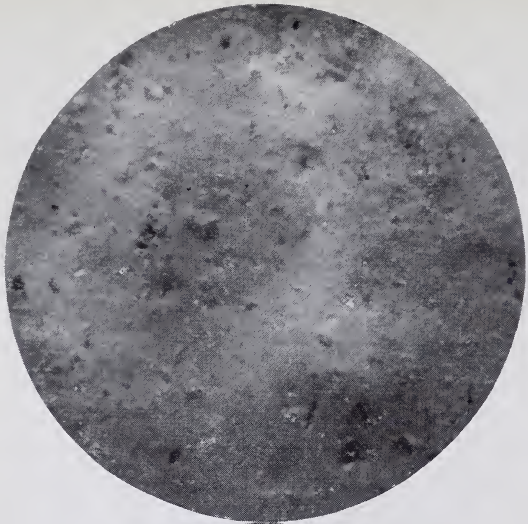
After Washing

Formula No. 7—Panel No. 14

	M. F.	C. A.
Basic Carbonate—White Lead	37%	37%
Zinc Oxide	63%	63%

Checking: Smooth surface.
Chalking: 4
Color: 15
Abrasion Resist: 24 lbs. emery.

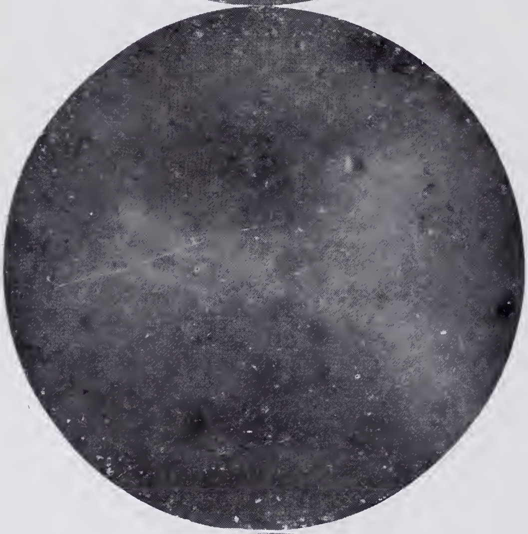




Formula No. 8—Panel No. 16

	M. F.	C. A.
Basic Carbonate— White Lead	38%	38%
Zinc Oxide	48%	48%
Silica	14%	14%

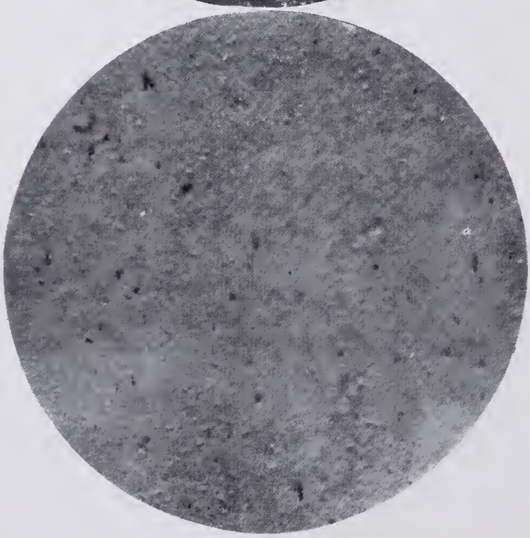
Checking: Smooth surface.
Chalking: 3
Color: 13
Abrasion Resist: 41 lbs. emery.



Formula No. 9—Panel No. 18

	M. F.	C. A.
Zinc Oxide	73%	75%
Silica	25%	23%
Calcium Carbonate	2%	2%

Checking: Smooth surface
Chalking: 2
Color: 20
Abrasion Resist: 19 lbs. emery.



Formula No. 10—Panel No. 20

	M. F.	C. A.
Basic Carbonate— White Lead	44%	45%
Zinc Oxide	46%	45%
Calcium Carbonate	5%	5%
Magnesium Silicate	5%	5%

Checking: Smooth surface.
Chalking: 6
Color: 8
Abrasion Resist: 29 lbs. emery.

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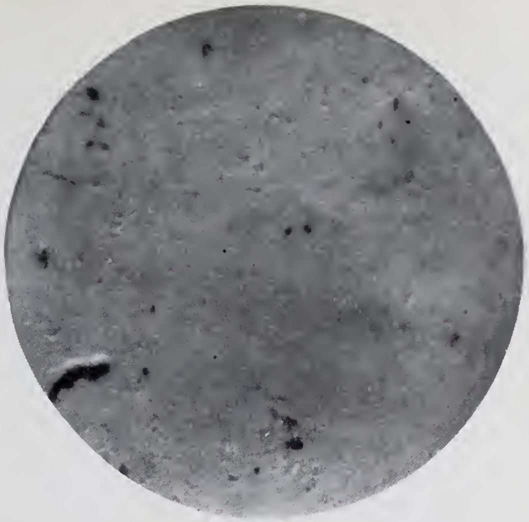
* Tentative

Formula No. 11—Panel No. 22

	M. F.	C. A.
Basic Carbonate—White Lead	50%	51%
Zinc Oxide	50%	49%

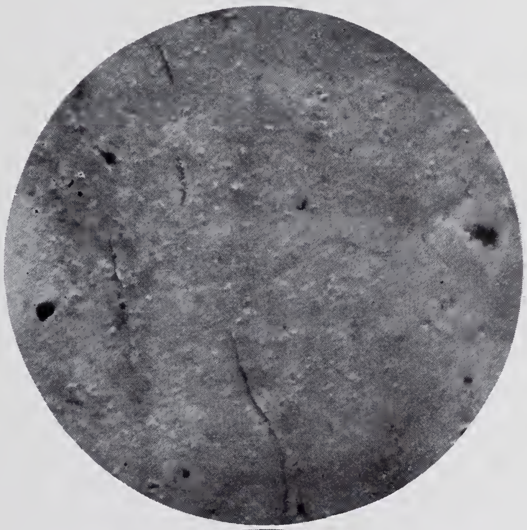
Checking: Foreign particles still present a film.
Chalking: 5
Color: 19
Abrasion Resist: 33 lbs. emery.



Formula No. 12—Panel No. 24

	M. F.	C. A.
Basic Carbonate—White Lead	60%	61%
Zinc Oxide	34%	35%
Inert Pigment	6%	4%

Checking: Beginning along the grain of the wood.
Chalking: 6
Color: 23
Abrasion Resist: 24 lbs. emery.



Formula No. 13—Panel No. 26

	M. F.	C. A.
Basic Sulphate—White Lead	60%	59%
Zinc Oxide	27%	29%
Magnesium Silicate	10%	8%
Calcium Carbonate	3%	4%

Checking: Smooth surface.
Chalking: 7
Color: 12
Abrasion Resist: 24 lbs. emery.

Formula No. 14—Panel No. 28

	M. F.	C. A.
Basic Carbonate—White Lead	25%	24%
Basic Sulphate—White Lead	20%	20%
Zinc Oxide	25%	27%
Calcium Sulphate	25%	24%
Calcium Carbonate	5%	5%

Checking: Mottled effect due to foreign particles.
Chalking: 4
Color: 12
Abrasion Resist: 28 lbs. emery.

Formula No. 16—Panel No. 32

	M. F.	C. A.
Basic Carbonate—White Lead	33%	32%
Zinc Oxide	33%	34%
Barytes	34%	34%

Checking: Scars are plainly evident.
Chalking: 4
Color: 15
Abrasion Resist: 25 lbs. emery.

Formula No. 15—Panel No. 30

	M. F.	C. A.
Zinc Lead White	30%	29%
Zinc Oxide	40%	41%
Basic Carbonate—White Lead	20%	20%
Calcium Carbonate	10%	10%

Checking: Smooth Surface.
Chalking: 4
Color: 12
Abrasion Resist: 35 lbs. emery.

In Atlantic City panel surface much checked which caused rapid abrasion.

Formula No. 17—Panel No. 34

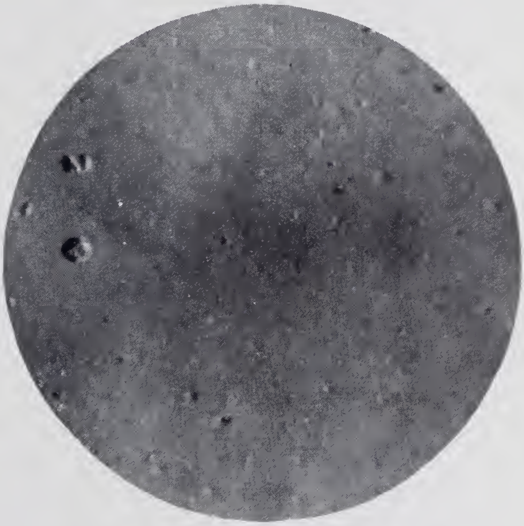
	M. F.	C. A.
Barytes	13%	14%
Blanc Fixe	4%	4%
Asbestine	3%	3%
Zinc Oxide	40%	42%
Basic Carbonate—White Lead	40%	37%

Checking: Scars evident.
Chalking: 6
Color: 11
Abrasion Resist: 18 lbs. emery.

Formula No. 18—Panel No. 36

	M. F.	C. A.
Basic Carbonate—White Lead (in oil)	75%	78%
Zinc Oxide (in oil)	25%	22%

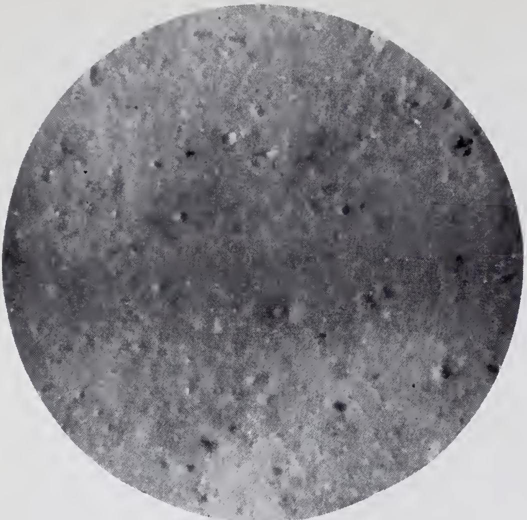
Checking: Smooth surface.
Chalking: 9
Color: 15
Abrasion Resist: 31 lbs. emery.



Formula No. 19—Panel No. 38

	M. F.	C. A.
Basic Sulphate—White Lead (in oil)	75%	66%
Zinc Oxide (in oil)	25%	34%

Checking: Smooth surface.
Chalking: 10
Color: 7
Abrasion Resist: 31 lbs. emery.



Formula No. 20—Panel No. 40

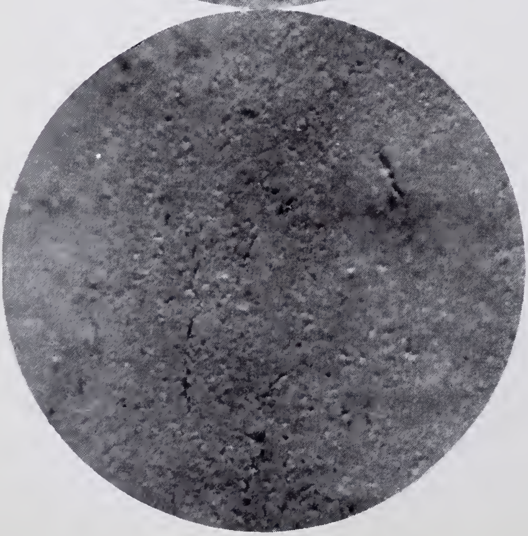
	M. F.	C. A.
Basic Carbonate—White Lead	67.0%	67%
Zinc Oxide	19.5%	20%
Asbestine	3.5%	3%
Calcium Carbonate	10%	10%

Checking: Smooth surface.
Chalking: 8
Color: 19
Abrasion Resist: 28 lbs. emery.

Formula No. 33—Panel No. 168

	M. F.	C. A.
Zinc Oxide	30%	32%
Special Silica	30%	30%
Basic Carbonate—White Lead	15%	14%
Basic Sulphate—White Lead	25%	25%

Checking: Scarred appearance evident.
Chalking: 6
Color: 10
Abrasion Resist: 41 lbs. emery.



Formula No. 34—Panel No. 172

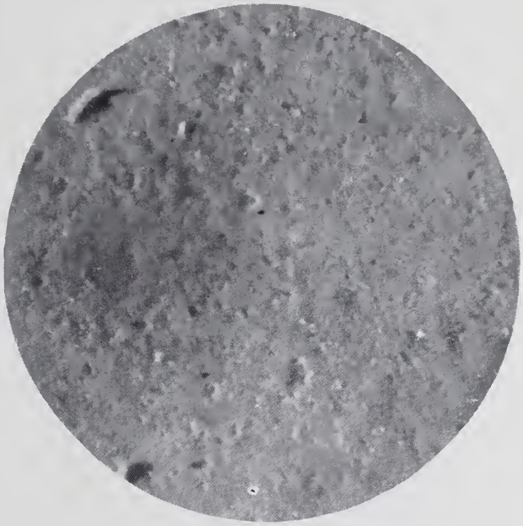
	M. F.	C. A.
Basic Carbonate—White Lead	38.95%	38%
Basic Sulphate—White Lead	4.81%	4%
Zinc Oxide	33.58%	34%
Calcium Carbonate	19.48%	19%
Barytes & Silica	3.18%	5%

Checking: Evident.
Chalking: 7
Color: 6
Abrasion Resist: 39 lbs. emery.

Formula No. 35—Panel No. 173

	M. F.	C. A.
Basic Carbonate—White Lead	37.51%	39%
Basic Sulphate—White Lead	7.84%	8%
Zinc Oxide	25.87%	25%
Calcium Carbonate	20.36%	19%
Barytes & Silica	8.42%	9%

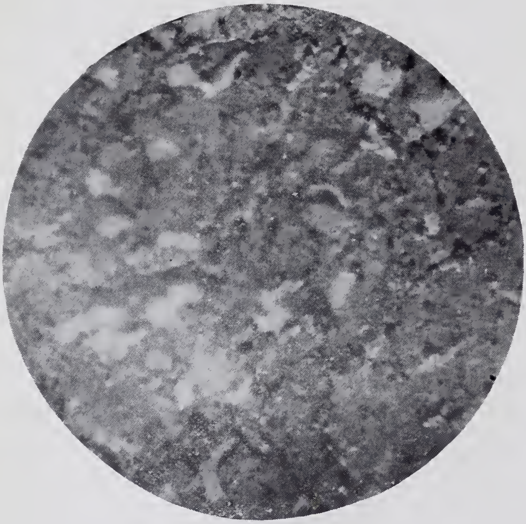
Checking: Smooth appearance.
Chalking: 5
Color: 6
Abrasion Resist: 42 lbs. emery.



Formula No. 39—Panel No. 177

	M. F.	C. A.
Zinc Lead	100%	100%

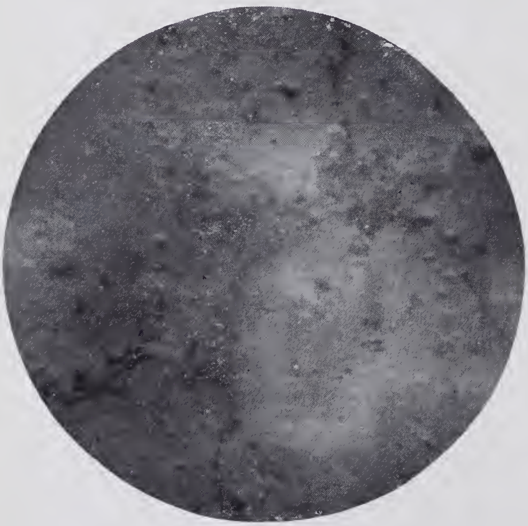
Checking: Small particles of foreign matter still apparent.
Chalking: 2
Color: 20
Abrasion Resist: 58 lbs. emery.
Very tough surface.



Basic Carbonate—White Lead
Panels on Fence.

Before Washing

Peculiar network-like checking appearing through outer coat of impurities.



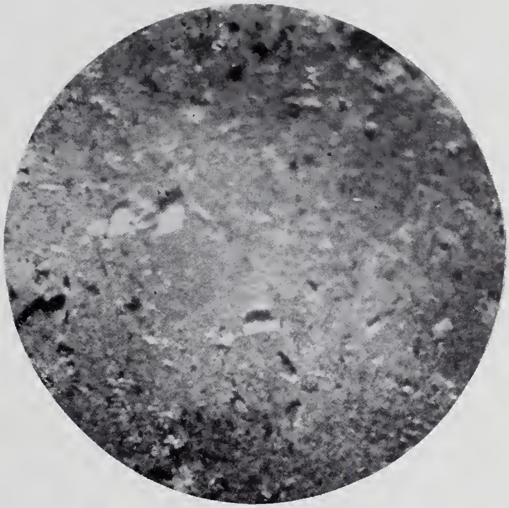
After Washing

Formula No. 36—Panel No. 174

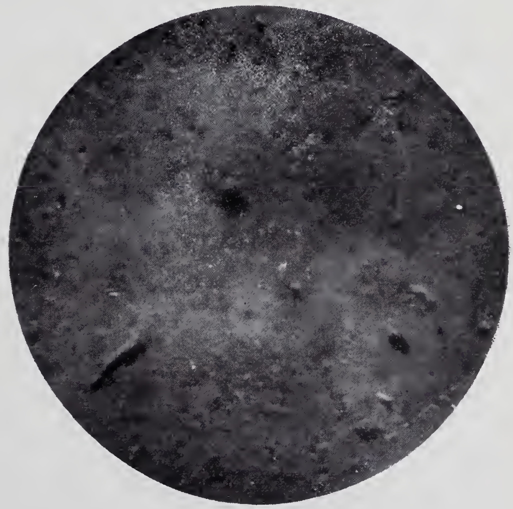
		M.F.	C. A.
Basic Carbonate— White Lead Type "B"		100%	100%

Checking: Advancing in the usual way.
Chalking: 10
Color: 15
Abrasion Resist: 26 lbs. emery.

Before Washing



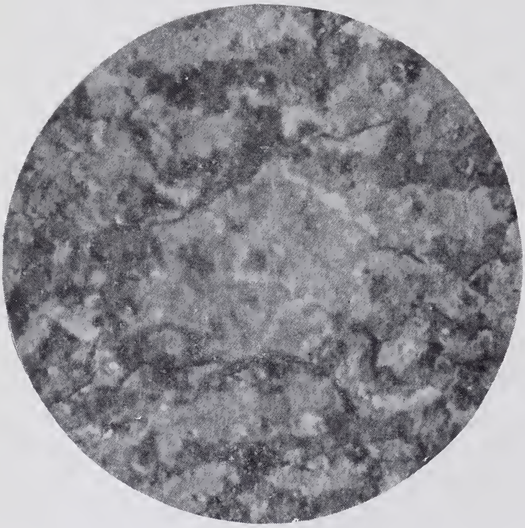
After Washing



Formula No. 37—Panel No. 175

	M. F.	C. A.
Basic Carbonate—White Lead Type "C"	100%	100%

Checking: Checking only slightly evident.
Chalking: 10
Color: 15
Abrasion Resist: 26 lbs. emery.



Basic Carbonate—White Lead
Panels on Fence.

Before Washing

Checking evident even through the outer covering of foreign matter.

After Washing

Formula No. 38—Panel No. 176

		M. F. C. A.
Basic Carbonate—White Lead Type "A"	100%	100%

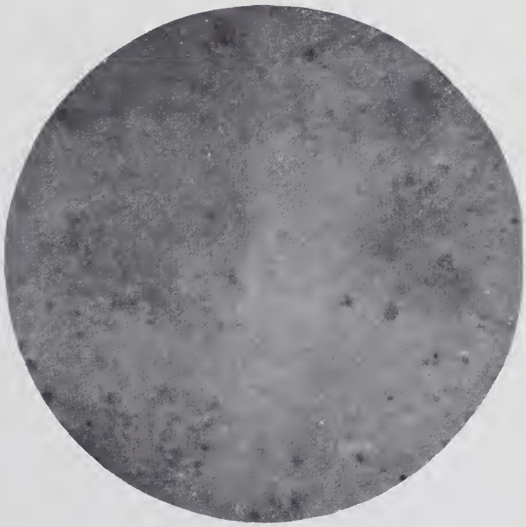
Checking: Characteristic checking of white lead very apparent.
Chalking: 10
Color: 14
Abrasion Resist: 24 lbs. emery.

Formula No. 40—Panel No. 178

	M. F.	C. A.
Basic Sulphate— White Lead	100%	100%

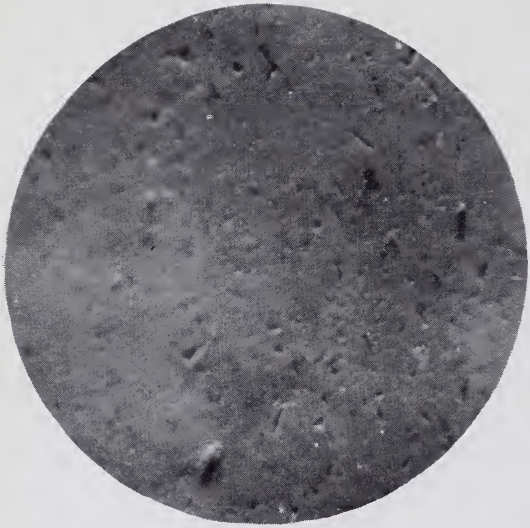
Checking: Surface free from checking.
Chalking: 10
Color: 13
Abrasion Resist: 31 lbs. emery.

Formula No. 45—Panel No. 169



	M. F.	C. A.
Zinc Oxide	90%	91%
Calcium Carbonate	10%	9%

Checking: Smooth surface.
Chalking: 1
Color: 8
Abrasion Resist: 56 lbs. emery.



Formula No. 46—Panel No. 170

	M. F.	C. A.
Zinc Oxide	61%	61%
Barytes	39%	39%

Checking: Scarred appearance.
Chalking: 2
Color: 10
Abrasion Resist: 36 lbs. emery.

Formula No. 47—Panel No. 171

	M. F.	C. A.
Zinc Oxide (ground in special boiled oil)	100%	100%

Checking: Smooth surface.
Chalking: 1
Color: 6
Abrasion Resist: 51 lbs. emery.

The Cause of Checking and the Characteristics of Fine Matt Checking

By R. S. PERRY

In the annual inspections of the Pittsburg and Atlantic City Test Fences, fine matt checking was observed, and record made thereof, but the publication of the observations was withheld from the annual reports.

Efficient hand-magnifying glasses were used in these annual inspections, but without full explanation of the phenomenon, confirmed by high power microscope work, misunderstanding of the meaning of fine matt checking might have resulted, and injustice might have been done to many paint formulas.

The words, "fine matt checking," have been used by the Scientific Section throughout to describe a very distinct change in the conformation or body of the paint coating, a change which may or may not be acompanied by an actual breaking or fracture in the continuity of the paint coating, but a change which clearly and unquestionably indicates the beginning of true checking or actual fracture of the paint coating.

The Scientific Section, by the use of the expression, "fine matt checking," describes a visible formation of elevations or depressions above the normal plane or original surface of the paint coating, as seen under the microscope (at 33 diameters magnification).

Long ridges are the most noticeable and usual phenomenon, with comparatively sharp crests, and the larger proportion of these crests have split apart or fissured, thus inaugurating actual checking.

The photomicrographic illustrations of this fine matt checking under the microscope are somewhat deceptive, because the sharp crest appears in the picture as a fracture or split of the paint coating in instances where the crest has not yet actually broken, but in the coarser checking the photomicrograph clearly depicts actual conditions.

The characteristic phenomenon in fine matt checking is the formation of elevations or depressions and with a sharp crest to the ridge, and this is an absolute forecast of a fracture, whether the fracture has appeared or not at the moment of observation, because a sufficient percentage of fractures identical with the crests of the ridges clearly demonstrates the fate of the remaining crests.

Simple laws governing physical forces when exerted in lateral surface strains, would appear to entirely account for these vertical movements of the paint coating, and they are the same laws which, acting on the shrunken surface of the earth, have produced mountain ridges and valleys and fissures or faults such as accompanied the San Francisco earthquake.

In the writer's address before the Michigan Chapter of the American Institute of Architects, on June 4, 1907, the statement was made, that the paint coating must be conceived of as a flat arch, and the structure upon which the paint is applied, as supporting false work thereunder.

Taking the aggregate of these flat arches, and passing to the wider conception of the broad area of the paint coating, we can compare this coating or crust with the flat arch structure of a concrete floor, or, again, with the crust of the

earth, and we perceive the same phenomenon in the paint coat ridges of fine matt checking that we see in the buckling of a concrete floor where unequal strains are developed upon abnormal shrinkage, or the above-mentioned phenomenon of the mountain ridges of the earth's crust.

When the paint coating is under the microscope, if the area examined be placed so that the light falls across the direction of the checks, the ridges will be very apparent, but the actual faulting or cracking of the paint coating will be largely concealed. If the light strikes the microscope field along the lines of checking, then in that case the perspective largely disappears, by which the ridges or folds can be viewed, but the checking then becomes very apparent if present, and is measurable with great accuracy. These folds or ridges sometimes follow the grain of the wood, especially on hard grained woods, but on soft pine the direction of these ridges is more apt to be governed by other factors.

Under the microscope, fine matt checking looks singularly like a bird's-eye view of the earth's crust, or the appearance of a relief map of the earth (a body in which the strains have not yet become unduly destructive), while the paint coatings with coarse matt checking look singularly like a telescopic view of the surface of the moon (where destructive shrinking has taken place).

Whenever a crust or superficial coating shrinks, lateral push or pull may develop as a force which tends to ridge or fold.

This lateral force is contrasted with forces such, for example, as volcanic craters or where moisture in lumber exerts a pressure that breaks or explodes the paint coating, so admirably treated of in "Why Paint Peels," by G. B. Heckel.

To offset any strains which result in the ripening or drying of the paint coating, the paint manufacturer must rely upon counter forces.

These are elasticity and such strength reinforcers as may be obtained through the use of materials like asbestine.

Through its elasticity, the semi-solid linoxyn, with its contained particles of pigment which make up the coating of paint, may gradually accommodate itself to these lateral shrinkage strains.

The presence of ridges or folding is therefore indicative of elasticity, and a paint coating which shows low, fine, and infrequent ridgings is a paint of accommodating elasticity, whereas a paint coat in which the ridges are practically absent, but on which fine matt checking is profuse is a paint deficient in elasticity.

If, then, paint coatings are compared under the same exposure and for the same length of time, it may be said:

Where fine matt checking is not found or no ridges are formed, sufficient elasticity has been provided to enable the paint coating to entirely accommodate its structure to the strains, and in such case there is no indication that checking will be one of the causes of the final wearing away of the paint.

In the case where fine matt checking is observed, the microscope will show the following phenomenon, namely, when viewed under light which is transverse to the checking, comparatively parallel ridgings or foldings will appear, and when the same field is viewed under light parallel with the direction of the ridges, the ridges will be comparatively obscured, in which latter case the breaks or cracks in the paint film will be quite apparent.

Where such fine matt checking is found, sufficient elasticity has been provided to partially but not entirely enable

the paint coating to accommodate its structure to strains, and in the gradual wearing away of the paint coating, cracking will gradually develop as one of the causes of the wear, to which will be added the more rapid erosion or more rapid wearing away of the crests of the ridges from surface wear.

Therefore, the condition of the surface described by "fine matt checking" means that the fine cracks in the paint coating and the wearing off of the ridges in the paint coating are both of them extra factors in the wearing of the paint coating, as compared with a paint coating in which no ridging and no cracking whatever has occurred, but it is quite possible that average and proper surface wear may progress at such a rate that the fine matt checking will not be a serious factor in shortening the life of the paint.

Coarse checking means that checking will be a dominant influence in the perishing of the paint coat and that their final breakdown, if from checking, will precede those formulas which show no ridges or no fine matt checking.

This resume of the forces which have been studied by the Scientific Section during the past two years is to prevent misunderstanding of the nomenclature which the Scientific Section is using, and in simple justice to those formulas which show only fine matt checking.

CATALOGUE

Library of the Scientific Section

Petroleum and Its Products—2 Vols. —*Sir Boverton Redwood*

A Treatise on its Distribution, Occurrence, Physical and Chemical Properties, Refining and Uses

Handbook on Petroleum —*Thomson Redwood*

A Treatise on the Industrial Use of its Products.

Simple Methods for Testing Painters' Materials —*A. C. Wright*

Letters to a Painter —*Ostwald-Morse*

On the Theory and Practise of Painting

Iron Corrosion and Anti-Corrosive Paints —*L. E. Andes*

Dictionary of Chemicals and Raw Products —*G. H. Hurst*

Used in the Manufacture of Paints, Colors, Varnishes and Allied Preparations

Oil Colors and Printers' Inks —*L. E. Andes*

A Practical Handbook Treating of Linseed Oil, Boiled Oil, Paints, Artists' Colors, Lamp Black, and Printers' Inks

Manufacture of Mineral and Lake Pigments —*J. Bersch*

Containing Directions for the Manufacture of All Artificial Artists' and Painters' Colors, Enamel Colors, Soot and Metallic Pigments

Chemistry of Paints and Painting —*A. H. Church*

Painters' Laboratory Guide —*G. H. Hurst*

A Handbook on Paints, Colors and Varnishes

Pigments, Paints and Painting —*A. T. Terry*

A Practical Book for Practical Men

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Concrete Coatings

By HENRY A. GARDNER

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CONCRETE COATINGS

By HENRY A. GARDNER

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CONTENTS

Treatment of Concrete Surfaces

Growing Demand for Concrete

Wonderful development in the production of cement has been made during the past decade, and it is believed by some recognized and prominent engineers that cement is destined to be the standard building material of the future. Cement is the natural substitute for lumber, and the progress being made at the present time to conserve lumber and steel will further encourage the use of substitutes for these materials for which there is an ever-increasing demand. It is therefore evident that the use of cement will grow, and within a few years its present demand may be doubled.

Necessity of Protection

The rapid development in the use of cement and concrete for structural purposes, and the diversity in their field of application, makes the study of a paint coating therefor a very vital and important problem. Cement, from its very composition and method of manufacture, contains free lime or develops within itself free lime, after setting. Various methods have been tried out to overcome the effects of this free lime, and to neutralize it before the application of oil coatings so that it would have no action in destroying these oil coatings.

Physical Properties

The cement engineer is studying the elasticity, tensile strength, elongation, flexure, and other physical characteristics of cement and concrete, upon which he bases his calculations when designing a structure. It is evident, therefore, that the paint chemist should in a like manner study from every standpoint the problem of the paint coating which is to be applied, in order that results may be obtained which will be permanent and satisfactory.

Decoration of Concrete Houses

The immense strides recently made by cement engineers in the construction of houses of concrete, have not been met by the painter in equal advances toward the proper decoration of such houses. The unsightly appearance of concrete unless decorated is such that homes of this material will not be popular unless proper methods have been worked out for their decoration. It has been found that the addition of approximately 5% of lampblack, ochre, Venetian red, and one or two other paint pigments, may be made to concrete, without affecting its strength to any extent, and will render such concrete more pleasing to the eye, giving slate, buff, terra-cotta and other colors. These pigments, however, do not waterproof, nor are they as pleasing in appearance as oil coatings.

Protection of Reinforced Concrete

Reinforced concrete for floors, arches, walls, etc., is being used in immense quantities, and if the engineer demands that this material be water-proofed and decorated, it is the duty of

the chemist and engineer to discover not only the best method of water-proofing and painting these concrete surfaces, but to discover some material for such purposes which will at the same time have no deleterious effects upon the steel rods of the reinforcing material.

Theory of Voids

Engineers have tried to obtain water-proof structures of concrete by adjusting the size of the particles and quantity of the particles of stone, cement and other constituents of the concrete. It is right here where the law of minimum voids, which applies to paint coatings as well as to concrete, were first developed by eminent cement technologists.

Cementing Values

The ultimate strength of concrete depends largely upon its "aggregate" (percentage of broken stone, gravel, sand and cement). It is only the extremely fine powder of cement that has cementing and adhesive properties, the larger particles being inert, and it is for this reason that a finely-ground cement will take up more sand and stone and form a better structural material than one less finely ground. It is for the cement engineer, however, to work out to his own satisfaction those proportions which are eminently and best suited to the construction of cement houses.

Waterproofing Tests and Effects

A special committee appointed by the American Society for Testing Materials undertook a series of tests on briquets of cement mortars, in different proportions, and it was demonstrated that untreated mortars of certain

sands, even as low as four to one, could be made fairly water-proof, without special treatment, while those mixtures of lower-grade sands were inferior in this respect. It was also demonstrated that treatment with certain chemicals waterproofed the mortars to a great extent; due to the mechanical improvement of the mortars by an increase in their granulometrical values, through the filling of their voids, either from a mechanical or physical standpoint. Marked impermeability was obtained in some cases with very little impairment of strength. In some cases, however, a loss of strength and a weakening was shown, although the impermeability was increased.

Action of Sea Water on Concrete

Le Chatelier, Jewett and others have pointed out that concrete is disintegrated to a great extent by sea water containing certain soluble salts. This action is largely due to the formation of, possibly, calcium and magnesium sulpho-aluminates, through combination with the aluminum content of the cement, causing subsequent crystallization, swelling and cracking. It has been the belief of most cement engineers, however, that any increase in volume from the above chemical changes would be so slight that the destructive effect taking place therefrom would be counteracted and prevented from continuous action by the filling of the pores of the concrete, with its consequent impervious rendition.

Tests of the effect of certain salts upon the

tensile strength of concrete have been made. Briquets of cement when set in sodium carbonate instead of water showed an actual increase in strength. This is probably due to the neutralization of the free lime in the cement with the formation of calcium carbonate, which fills up the pores.

Effect of Sodium Carbonate

Seepage has always been a great destructive agency that has bothered the engineers of both continents for some time. The underground subways in New York city and the many tunnels under the rivers, in which enormous quantities of concrete and cement are used, are subjected to this seepage, and in many cases this seepage has been so serious that the structural steel used in the tunnels has been corroded to a considerable extent.

Seepage and its Effects

It has been found by S. E. Thompson that hydrated lime actually is effective in increasing the water tightness of concrete, and when using one part of Portland cement, two parts of sand and four parts of stone, 8% of hydrated lime has been found of the greatest value for this purpose. Free lime or uncombined lime, however, causes unsoundness if not perfectly hydrated. Excessive lime causes disintegration. It is an actual fact, however, that sulphate of lime actually makes good, certain unsound, cements, and it is therefore natural to consider the transformation of free lime into sulphate of lime by the use of zinc sulphate, an actual improvement in the cement, not only in its re-

Effect of Hydrated Lime

Effect of Zinc Sulphate

duction of suction qualities, but in an increase in its tensile strength and a lessening of porosity.

Suction and its Effect on Paint

The suction properties of cement must be considered very carefully. We have found that ordinarily all paints which will spread about four hundred square feet, two-coat work, upon wood, will not spread over three hundred square feet, one-coat work, on concrete because of the enormous suction taking place, and this is largely due to the porosity of the cement or concrete. When it is considered that cement and concrete contain innumerable pores it is only fair to believe that these pores should be filled up and properly treated so that no suction will take place before the application of any oil coating, and this must be done at no great expense to the tensile or shearing strength of the cement itself.

Determination of Suction

A very ingenious method of showing the absorption or suction of concrete may be made by taking an ordinary weighed concrete briquet and covering it with a piece of heavy felt saturated and kept saturated with water. Weighings may be taken every hour to determine the amount of water which is taken up by suction. The amount of water absorbed in this manner is often very great.

Priming Coat for Cement

In painting wood, the paint is absorbed and soaked into the fibre of the wood to quite a depth. On hard wood the penetration by the priming coat which is necessary as a binder or

foundation for subsequent coats is assisted by the use of turpentine which possesses penetrative qualities of distinct merit. When concrete is painted, the same law on the priming coat might be observed with success.

The very porosity of concrete and its suction might be considered as properties that make it a most successful surface for painting. It takes the paint up readily and forms a good surface for subsequent coats, which, if properly applied, should not act in the same manner as they often do on wood where peeling and scaling so often take place.

Oil Coatings of Great Value on Concrete

Although it has been claimed by White* that a proper cement coating should not contain oil of a saponifiable nature, it is our opinion that oil coatings would be very satisfactory when the concrete has received proper treatment previous to the application of the oil coatings. It is very evident that if one can secure neutralization of the lime in concrete and filing of the voids, so as to nullify the suction after the ultimate set of the concrete has taken place, and do so with no material loss to tensile strength and with no danger of efflorescence or other action to destroy the oil coating, then oil coatings may be placed upon concrete with not only as great a preservative effect, but with an equally good decorative effect as upon iron or steel.

Concrete properly aged by standing a year

* American Society for Testing Materials.

Artificial Ageing of Concrete Previous to Application of Coatings

or two before painting has been painted with linseed oil coatings with considerable success. Therefore, is it not reasonable to assume that an artificial method of ageing concrete, which will not only kill the action of lime, but nullify the suction properties of the cement, should afford a surface upon which oil coatings may be applied with success? Oil coatings have greater life and endurance than most any other coatings known or used in decorative art. Various mixtures and compounds of asphaltum and coal tar products and gums admixed with volatile solvents have been tried out as water-proof and damp resist paints on concrete with more or less success. Their color, however, is not satisfactory, and as the visual and decorative effect is of great importance, especially in considering paint for concrete houses, it seems improbable that this class of paints will come into any considerable use, and, further, that oil coatings must be used to fulfill and meet all the demands for an ideal coating.

"Macnichol" or Zinc Sulphate Treatment of Concrete Previous to Coating with Oil Paints

There has appeared in several trade journals lately articles on the painting of cement, and there was read before a master painters' convention during the past year a paper on this subject by Charles Macnichol, of Washington, who is probably the first master painter in the country to use to any extent the so-called "zinc sulphate method." The "Macnichol Method" has been suggested as the proper name for this treatment. In Mr. Mac-

nichol's paper there is outlined the chemical reaction which takes place when zinc sulphate is applied to concrete. The action of the free lime developed in the concrete is to combine with the sulphuric acid portion of the zinc sulphate, and precipitate calcium sulphate or gypsum, while the zinc itself is thrown down as a hydrate. It is thus evident that there is precipitated within the pores of the concrete two pigments, both neutral, and which tend to fill up the voids and pores and neutralize to some extent the suction properties of the concrete, thus giving a surface upon which oil coatings may be applied. Whether an excess of zinc sulfate in this treatment would do harm, has not yet been determined.

Ammonium Carbonate Treatment and its Defects

Mr. Macnichol also mentions the ammonium carbonate treatment, which consists in applying to concrete a solution of ammonium carbonate in water. It is well known that soluble ammonium salts when in the presence of free lime or other strong alkalies, decompose, the weaker ammonium base being driven off by the stronger alkali (which, in the case of concrete, is lime) combining with the carbonic acid to form calcium carbonate, another excellent paint pigment which fills up the voids and stops suction to some extent. It is the author's opinion, however, that the ammonium carbonate process is not fitted for the treatment of cement, inasmuch as the ammonia which is given off is even a greater danger to oil coat-

ings than free lime itself. As was stated by Mr. White in a paper presented before the American Society for Testing Materials, there is no definite method of ascertaining just how much free lime is present in the concrete at the time it is treated with a soluble salt such as ammonium carbonate, and therefore if an excess of the ammonium carbonate were used it would remain within the pores of the concrete unacted upon. If, after an oil coating were applied, the free lime in the concrete started to develop it would act upon the ammonium carbonate left in the pores of the concrete, and ammonia would again be developed and would naturally seek the surface, where it would strike the oil coating and have its saponifying effect, causing very disastrous results.

Soda Water Treatment

The carbonic acid treatment, as proposed by Dr. Thompson, has not met with very much success, and is not considered practical by some master painters on account of its high cost and difficulty of application. This process consists of the spraying of the walls of concrete with a solution of ordinary soda water, which, chemically, is water charged with carbonic acid gas. This solution when applied to concrete might in the presence of free lime neutralize the free lime to some extent.

Investigations Undertaken by Scientific Section

The Scientific Section secured a series of compounds widely advertised for use in treating cement either to render it water-proof, to conserve its strength or add to its decorative

appearance. Analyses of these compounds brought out some interesting information which will be given in a general way in this book.

Stearic Acid Compounds

Among the materials analyzed were several solutions. One of these (Solution X) contained approximately 5% of pigment and 95% of vehicle. The pigment was composed of stearic acid and gum, while the vehicle was composed of nearly equal parts of benzine and amyl acetate. This solution when applied to concrete coatings deposited within the concrete, to such an extent as it impregnated the concrete, the stearic acid and the gum, the volatile part of the liquid being evaporated. After treatment with this compound the concrete would offer more or less resistance to water, but it was found that the compound possessed very little action in filling the pores of the concrete, and thus failing to stop the suction of the concrete, was of no great value in rendering concrete surfaces ready for painting. It failed to have any action in neutralizing the free lime, and for this reason would be of little value when subsequent coats of oil paints were to be used.

Another solution which had a very attractive name will be called solution XX. This consisted of stearic acid, benzine and other volatile solvents. It was of approximately the same value as solution X.

One solution, upon analysis, was shown to

Saponaceous Solutions

contain nearly 85% of water, the balance being linseed oil and soap. It can be plainly seen that the master painter himself could make an equally good compound at a great saving of money. When applied to concrete the water carries the soap and oil into the pores thereof, and when the water evaporates there is left within the concrete a partially saponified soap which, in the presence of free lime, might precipitate a hard, insoluble lime soap. This solution will be called XXX.

Chloride Solutions and their Properties

Solution XXXX may be taken as an example of many waterproofing compounds on the market. This is a water solution of calcium chloride, containing about one-third its volume of the dry salt. Other solutions of a similar nature were found to contain calcium and zinc chlorides. No definite decision has been reached as to the effect of these compounds upon cement, except that they cause rapid hardening and setting, but physical tests of cements and concretes mixed with or treated with such compounds should be made in order to ascertain whether the tensile strength is affected in any way by their use. If they cause an acceleration of the initial setting point they may be dangerous.

There are several dry powders upon the market containing various proportions of zinc, calcium and other chlorides, for which wonderful virtues have been claimed. Mixing these powders with the cement previous to the ap-

plication of the cement may add to the cement's value, but a point to be considered in this connection is whether the strength of the cement is affected. It is well known that the "initial set," so-called, of cement takes place after water has been added and when the paste ceases to be fluid. The "final set," so-called, requires a certain time limit for the cement and concrete to acquire any degree of hardness. Now, it is an established fact that cement and concrete should be applied within a certain time limit after mixing, so that no crystallization or disturbance will take place before it has acquired its "initial set" in its resting place. Some of the compounds referred to for water-proofing cement, when used in considerable quantity, undoubtedly affect this initial set to some extent, either stimulating or retarding, and therefore it is an open doubt in the minds of some engineers as to the advisability of their use.

Waterproofing Powders

There was obtained for analysis a paste which we will call V. This paste in appearance resembles a soft wax, but when placed in water it is found to be partially soluble. The directions for its use call for certain proportions to be dissolved in hot water and added to the cement or concrete at the time of mixing. From its composition, which chemical analysis shows to be approximately fifty parts of soap with some free alkali, 35% of water and 15% of silica, we would judge that the

Waterproofing Pastes

free lime in cement would act upon the soap, forming insoluble calcium oleates which might help to some degree in rendering the cement water-proof, but the objection above stated, to the use of such compounds, also applies in this case. It is our opinion that the water-proof rendition of cement and concrete surfaces should take place after the final set of the surface, so that no crystallization or other molecular disturbances should be introduced.

Asphaltum Paints for Concrete

There are several compounds of tar and asphaltum being used to-day to some extent for application to concrete in order to make it damp resisting, and the analysis of one shows 40% of a high boiling point paraffine spirit and 60% of a tar base, evidently obtained from the distillation of wood. We will call this compound XV. Upon application it dries with a very glossy surface, but the film remains very soft. Such compounds undoubtedly possess considerable merit as excluders of moisture and water, but it is a proven fact that when made of cheap grades of asphaltum the action of the sun's rays decompose them to a certain extent, possibly with transformation to carbon, which becomes hard and brittle and flakes off after a certain period of wear. Unfortunately, these compounds are all very dark in color, and it would be impracticable to apply over their surface lighter oil colors.

There is used at the present time by some prominent master painters a paint which

is made as a first-coater and second-coater for concrete. Both the first-coater and the second-coater in the pigment portion consist largely of zinc, silica and gypsum, and the vehicle of the first-coater contains nearly one-third benzine, which aids in bringing the pigment in more intimate contact with the pores of the cement. There is, however, in this paint no provision for the neutralization of free lime which is present or which is afterward developed in the concrete surface, and it has been claimed by some that when this compound is painted with delicate colors affected by lime that unsatisfactory changes will take place.

Oil Coatings of Value

Another compound, similar in its pigment portion, we will call XXV. This consists largely of zinc oxide, whiting and silica in the pigment, ground in a small percentage of oil.

It is in very thick paste form and recommendation for reduction with considerable volatile spirit is made. It dries flat. Practical tests of this material prove that a larger percentage of vehicle of a drying nature would make it superior to its present state.

As a result of the practical tests now being made by the Scientific Section, it is hoped that information will be obtained which will enable the production of far better compounds for the painting of cement and concrete. Such tests as have already been made will doubtless prove of the greatest value, and further tests along the same lines will be inaugurated in the near future.

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By HENRY A. GARDNER

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3500 Grays Ferry Road, Philadelphia

PRESENTED BEFORE THE FORTIETH ANNUAL CONVENTION OF THE MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION OF THE UNITED STATES & CANADA

NIAGARA FALLS, NEW YORK, SEPTEMBER 14th, 1909

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DIAGRAM

PAINT TEST–STEEL FENCE
ATLANTIC CITY, N. J

H. A. GARDNER
DIRECTOR OF TEST
SCIENTIFIC SECTION
PAINT MANUFACTURERS ASSOCIATION

FENCE Nº 1

Front	Back
I 1	I 1
I 2	I 2
I 3	I 3
I 4	I 4
I 5	I 5
I 6	I 6
I 7	I 7
I 9	I 8
I 10	I 10
I 12	I 12
I 14	I 14
I 15	I 15
I 16	I 16
I 17	I 17
I 19	I 19
I 20	I 20
I 21	I 21
I 24	I 24
I 27	I 27
I 28	I 28
I 29	I 29
I 30	I 30
I 31	I 31
I 32	I 32
I 33	I 33
I 34	I 34
I 36	I 36
I 39	I 39
I 40	I 40
I 41	I 41
I 44	I 44
I 45	I 45
I 48	I 48
I 49	I 49
I 51	I 51
I B 111	I C 111
I B 222	I C 222
I C 333	I B 333
I C 444	I B 444
I C 555	I B 555
I C 666	I B 666
I C 777	I B 777
I C 888	I B 888
I C 2000	I B 2000
I C 3000	I B 3000
I C 4000	I B 4000
II B 100	II C 5555 2 Coats
II C 100	II B 5555 3 Coats
II B 90	II B 6666
II C 90	II C 6666
5555 Over Red Lead	I Steel with Scale No Paint
B 1000 1 coat	II C 7777
2 Plate Boiled Linseed oil 3 Coats	
*6 Steel Pickled	

FENCE Nº 2

Front	Back
II 1	II 1
II 2	II 2
II 3	II 3
II 4	II 4
II 5	II 5
II 6	II 6
II 7	II 7
II 9	II 9
II 10	II 10
II 12	II 12
II 14	II 14
II 15	II 15
II 16	II 16
II 17	II 17
II 19	II 19
II 20	II 20
II 21	II 21
II 24	II 24
II 27	II 27
II 28	II 28
II 29	II 29
II 30	II 30
II 31	II 31
II 32	II 32
II 33	II 33
II 34	II 34
II 36	II 36
II 39	II 39
II 40	II 40
II 41	II 41
II 44	II 44
II 45	II 45
II 48	II 48
II 49	II 49
II 51	II 51
II C 111	II B 111
II B 222	II C 222
II C 333	II B 333
II C 444	II B 444
II C 555	II B 555
II C 666	II B 666
II C 777	II B 777
II B 888	II B 888
II C 2000	II B 2000
II C 3000	II B 3000
II C 4000	II B 4000
II B 4444 2 Coats	I B 3333
II C 4444 2 Coats	III C 3333
II B 1000X	IV B 3333
II C 1000X	V B 3333
II Steel Pickled & Exposed No Paint	II Black Plate No Paint
B 1000 Chrome Resinate 2 Coats	
1 Coat Shellac with 10% Cr_2O_3	
*6 Steel Pickled	

FENCE Nº 3

Front	Back
III 1	III 1
III 2	III 2
III 3	III 3
III 4	III 4
III 5	III 5
III 6	III 6
III 7	III 7
III 9	III 9
III 10	III 10
III 12	III 12
III 14	III 14
III 15	III 15
III 16	III 16
III 17	III 17
III 19	III 19
III 20	III 20
III 21	III 21
III 24	III 24
III 27	III 27
III 28	III 28
III 29	III 29
III 30	III 30
III 31	III 31
III 32	III 32
III 33	III 33
III 34	III 34
III 36	III 36
III 39	III 39
III 40	III 40
III 41	III 41
III 44	III 44
III 45	III 45
III 48	III 48
III 49	III 49
III 51	III 51
III B 111	III C 111
III B 222	III C 222
III C 333	III B 333
III C 444	III B 444
III C 555	III B 555
III C 666	III B 666
III C 777	III C 777
III C 888	III B 888
III C 2000	III B 2000
III C 3000	III B 3000
III C 4000	I B 7777
III C 4000	I C 1111
I B 2222	IV B 1111
II C 2222	V B 1111
IV B 2222	IV Steel Without Paint
V B 2222	V Steel without Paint
III Pickled and Exposed	VI Steel Without Paint
Linseed Oil	
*6 Steel Pickled	

Nº 1 Dutch Process White Lead
Nº 2 Quick Process White Lead
Nº 3 Zinc Oxide
Nº 4 Sublimed White Lead
Nº 5 Sublimed Blue Lead
Nº 6 Lithopone
Nº 7 Zinc Lead White

Nº 9 Orange Mineral American
Nº 10 Red Lead
Nº 12 Bright Red Oxide (62 d)
Nº 14 Venetian Red
Nº 15 Princes Metallic Brown
Nº 16 Natural Graphite
Nº 17 Acheson Graphite

Nº 19 Lamp Black
Nº 20 Willow Charcoal
Nº 21 Gas Carbon Black
Nº 24 French Yellow Ochre
Nº 27 Barytes Natural
Nº 28 Barytes Precipitated
Nº 29 Calc. Carb. (Whiting)

Nº 30 Calc Carb Precipitated
Nº 31 Calcium Sulphate (Gypsum)
Nº 32 China Clay (Kaolin)
Nº 33 Asbestine (Silicate Magnesium)
Nº 34 American Vermilion (Chrome Scarlet)
Nº 36 Med. Chrome Yellow
Nº 39 Zinc Chromate

Nº 40 Zinc & Barium Chromate
Nº 41 Chrome Green (Blue Tone)
Nº 44 Prussian Blue (Stimulative)
Nº 45 Inhibitive Prussian Blue
Nº 48 Ultramarine Blue
Nº 49 Zinc & Lead Chromate
Nº 51 Magnetic Black Oxide

Nº 90 Straight Lamp Black Paint with Turps & Dryer
Nº 100 " " Carbon " " " " "
Nº 1000 Chrome Resinate in oil
Nº 2000 1 Coat Zinc Chromate 1 Coat Excluder
Nº 3000 1 " Lead " 1 " "
Nº 4000 1 " Red Lead 1 " "
Nº 111 Brown Inhibitive Paints

Nº 222 Black Inhibitive Paints
Nº 333 White " "
Nº 444 Green " "
Nº 555 Black Stimulative Paints
Nº 666 Brown " "
Nº 777 White " "
Nº 888 Green " "

Nº 1111 Green Special "G" Formula
Nº 2222 Red " " "
Nº 3333 Black " " "
Nº 4444 A. Excluder Paint
Nº 5555 Coal Tar Paint
Nº 6666 Special Paint
Nº 7777 Special Gl Paint

Analysis of Steel in Plates

	Nº 1 Fence	Nº 2 Fence	Nº 3 Fence	Nº 4 Fence	Nº 5 Fence	Nº 6 Fence
	Bessemer Steel	O. Hearth	Pure Iron	Special Bessemer Steel	Special Charcoal Iron	Spellerized Steel
Carbon	.08	.16	.03			
Manganese	.35	.44	Mere Trace			
Phosphorous	.08	.02	.005			
Sulphur	.05	.024	.024			

Roman Numerals = Class of Steel
Arabic Numerals = Number of Paint

"B" = Black Plates with scale
C = Pickeled Plates

Plates pickeled in Sulphuric Acid were used throughout on the pigments up to #51, using a definate spreading rate of 900 Sq. Ft per gallon in applying the paint. Above this number, cleaned plates were used with the definate spreading rate as above, and black plates were used without any spreading rate.

Excluding and Rust Inhibiting Properties of Paint Pigments for the Protection of Steel and Iron

By HENRY A. GARDNER

PRESENTED BEFORE THE FORTIETH ANNUAL CONVENTION OF THE
MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION
OF THE UNITED STATES AND CANADA

NIAGARA FALLS, NEW YORK, SEPTEMBER 14, 1909

PREFACE

The master painter will find herein a statement of the results obtained in the most recent study into the corrosion of iron and the development of protective coatings for the protection of iron. It is sincerely hoped that this pamphlet will be of considerable value to him in his work.

HENRY A. GARDNER

CHAPTER I

Results in Recent Testing of Pigments

Study of Corrosion Necessary when Designing Protective Coatings

The many theories, regarding the causes of the corrosion of iron, advanced during the last decade, have stimulated a great amount of original research on this subject by various investigators. In the course of these investigations the subject of protective coatings for iron and steel naturally has been brought into prominence and is receiving a considerable amount of attention.

The study of protective coatings for iron and steel, conversely, has led many interested paint manufacturers and users of painting materials to make a closer study of the causes of corrosion in order that they may know how to make and use better paints for protecting steel. In so doing, they have discovered that the two subjects are intimately connected and vitally important to each other.

No attempt will be made to cover the subject of the painting of steel cars or locomotives, or to outline any method for so doing, but the object of this paper is to bring before you as Master Painters, entirely new light upon the subject of pigments and their properties and values, so that you may, yourselves, select with good judgment the proper pigments to use for various purposes. If, in the past, you have been using pigments which are poisonous to

steel and which cause active corrosion, you should know it, and if, in the future, you can select pigments which are antiseptics and preventives of rust, you should use them.

A series of very interesting and instructive researches into the nature of the various paint pigments used in the painting of iron and steel, as a determining factor in the corrosion of iron, were recently made, and, as a result of these investigations, it has been possible for certain laws to be formulated, regarding the value of these pigments. Through a previous bulletin of the Scientific Section, namely, the "Preliminary Report on Steel Test Fences," the paint trade at large was informed of these investigations, but the results were withheld tentatively for the reason that the Scientific Section had no desire to publish any information, no matter how reliable the source from which it was obtained, without having absolute verification of results.

Results of Recent Tests on Nature of Pigments

The tests referred to were made upon fifty pigments largely used in the fabrication of paints, in order to determine which possess stimulative, which inert, and which inhibitive characteristics when in contact with steel in the presence of water. Bulletin No. 35, by Allerton S. Cushman, one of the foremost investigators in this line of research, was recently issued by the Office of Public Roads of the United States Department of Agriculture, and the results of these tests were published therein.

The paint manufacturer has drawn attention to the fact that some of these pigments which, in water, cause marked corrosion, when painted out in oil, give steel and iron immunity from corrosion for some period. The excluding value of such pigments may account for their protection for a certain time. However, when the film of oil has been destroyed, the pigment is subject to the moisture which acts to stimulate corrosion.

The following table is printed in Bulletin No. 35, by Allerton S. Cushman, of the United States Department of Agriculture:

BASIC CLASSIFICATION OF PIGMENTS

INHIBITORS	INDETERMINATES	STIMULATORS
Zinc Lead Chromate	White Lead (quick process, Basic Carbonate	Lamp Black
Zinc Oxide	Sublimed Lead (Basic Sulphate)	Precipitated Barium Sulphate (Blanc Fixe)
Zinc Chromate	Sublimed Blue Lead	Ocher
Zinc and Barium Chromate	Lithopone	Bright Red Oxide
Zinc Lead White	Orange Mineral (American)	Carbon Black
Prussian Blue (Inhibitive)	Red Lead	Graphite No. 2
Chrome Green (Blue tone)	Litharge	Barium Sulphate (Barytes)
White Lead (Dutch process)	Venetian Red	Graphite No. 1
Ultramarine Blue	Prince's Metallic Brown	Chinese Blue (Stimulative Prussian)
Willow Charcoal	Calcium Carbonate (Whiting)	
	Calcium Carbonate (precipitated)	
	Calcium Sulphate	
	China Clay	
	Asbestine	
	American Vermilion	
	Medium Chrome Yellow	

The following table gives the results obtained by the different investigators in determining by an accelerated test the relation of the various paint pigments in their effect on iron and steel in the presence of water. The losses

LOSS OF STEEL IN GRAMS IN TESTS CARRIED OUT ON PIGMENTS TO ASCERTAIN THEIR VALUE AS RUST INHIBITORS

	Pigment	Gardner No. 1 20 days	Cushman Nos. 1 & 2 10 days	Walker P. H. No. 2 $7\frac{1}{2}$ days	Cushman No. 2 10 days	Walker W. H. No. 1 ——	Aver'ge
1	Zinc Chromate	.0050	.0300	.0094	.0130	.0396	.0194
2	Zinc and Barium Chromate	.0153	.0468	.0034	.0140	.0351	.0229
3	Zinc and Lead Chromate	.0094	.0277	.0153	.0085	.0620	.0246
4	Zinc Oxide	.1524	.0296	.1002	.0085	.0504	.0682
5	Zinc Lead White	.0842	.1712	.0515	.0856	.0456	.0876
6	Barium Chromate	.2333	.0101	.0429	.0094	.1932	.0978
7	Ultramarine Blue	.0247	.3185	.0137	.1865	.0496	.1186
8	Chrome Green (blue tone)	.0860	.2269	.0548	.1240	.2346	.1453
9	Prussian Blue Inhibitive	.1438	.2267	.0448	.1130	.2671	.1591
10	Lithopone	.0160	.3791	.1274	.1792	. . .	.1754
11	Willow Charcoal	.1694	.2795	.1439	.1362	.2110	.1880
12	Litharge	.4325	.1932	.0309	.1584	. . .	.2038
13	Dutch Process White Lead	.2040	.2895	.1781	.1150	.2743	.2122
14	Quick Process White Lead	.2120	.3352	.1288	.1848	.2274	.2176
15	Calcium Sulphate	.3966	.2143	.1759	.1597	.2174	.2328
16	Prince's Metallic Brown	.3774	.2620	.1983	.1408	.1974	.2352
17	Orange Mineral French	.3950	.2724	.1495	.1467	.2526	.2432
18	Calcium Carbonate (Whiting)	.3828	.3620	.1384	.2380	.1208	.2484
19	Sublimed Blue Lead	.3177	.3425	.1001	.2365	. . .	.2492
20	Lemon Chrome Yellow	.2767	.4067	.1365	.1972	. . .	.2543
21	Orange Chrome Yellow	.2826	.4203	.1700	.1907	.2150	.2557
22	Medium Chrome Yellow	.4090	.3767	.1319	.1763	.2288	.2645
23	Chrome Green (yellow)	.3265	.3670	.1348	.1453	.3521	.2651
24	Venetian Red	.2682	.4756	.1955	.2375	.1564	.2666
25	Bone Black	.3392	.3245	.0921	.1413	.4401	.2674
26	Asbestine	.2394	.4025	.1748	.2240	.3405	.2762
27	Keystone Filler	.3560	.4651	.1366	.3349	.1481	.2881
28	Orange Mineral American	.4416	.4336	.1719	.2065	.2315	.2970
29	Umber	.1365	.5961	.1498	.3817	.2403	.3009
30	China Clay	.3493	.4770	.1248	.2445	.3212	.3034
31	Calcium Carbonate Precipitated	.3574	.4910	.1828	.2625	.2616	.3111
32	Red Lead	.3112	.3555	.1495	.1717	.5707	.3117
33	Prussian Blue Neutral	.3584	.4463	.1218	.2415	.4173	.3171
34	Indian Red	.3546	.3739	.2617	.1905	.4334	.3228
35	American Vermilion	.4328	.4147	.2612	.1877	.3387	.3270
36	Sublimed Lead	.4176	.5856	.0982	.2372	.3116	.3300
37	Sienna	.2876	.5432	.2949	.3085	.4462	.3761
38	Naples Yellow	.6482	.4800	.1512	.2347	.3846	.3797
39	Prussian Blue Stimulative	.5113	.4559	.2055	.2195	.5202	.3825
40	Mineral Black	.3050	.8018	.2017	.3529	.3353	.3993
41	Barytes	.4454	.5883	.2547	.3841	.5636	.4472
42	Natural Graphite	.4342	.5437	.2606	.3173	.7165	.4545
43	Bright Red Oxide	.3878	.7896	.2920	.3707	.4429	.4566
44	Acheson Graphite	.5262	.6337	.3723	.2789	.5095	.4641
45	Ochre	.4022	.8408	.2119	.4315	. . .	.4716
46	Carbonith White	.2655	. . .	. . .	. . .	.7152	.4904
47	Carbon Black	.5003	.6955	.4069	.3751	.5716	.5099
48	Precipitated Blanc Fixe	.5247	.8806	.3132	.5085	.5064	.5467
49	Lamp Black	.7180	1.3098	.2838	.7096	.6257	.7294

in weight measure the amount of corrosion. The most inhibitive head the list and the most stimulative are at the bottom.

CHAPTER II

Pigments in Aqueous vs. Oil Medium

Objections Offered to These Tests

Some objections were made by chemists to the tests of the different pigments in water medium, on the ground that pigments which might stimulate corrosion in the presence of water would not do so in oil medium. Claims were made that oil acts as an envelope for the pigment particles, and being a non-conductor of electricity, prevents any electrolytic action taking place on the steel plates upon which they are painted out.

Tests Made with Pigments in Oil

These objections suggested some rather interesting experiments. Upon several slides of glass, such as are used for mounting microscopic specimens, were painted out various pigments ground in oil. Upon these plates of glass thus painted and after they were properly dried, were firmly secured small strips of copper at either end. To the ends of the strips of copper were attached the wires of an ordinary dry cell. Into this circuit was placed a very delicate galvanometer. It was found that absolutely no current flowed through the paint film, and the galvanometer needle remained in its original position, at zero.

Results Confirm Previous Work

The glass slides were then removed from the apparatus and immersed in water for a while, during which time they were penetrat-

ed by the water to a certain extent, thus duplicating in a quick way the action of rainstorms upon paint coatings over an extended period. The slides were removed from the water and, after being carefully wiped off, were again connected up in the apparatus.

Conductivity of Moist Films by Stimulative Pigments

Non-Conductivity of Moist Films of Inhibitive Pigments

It was then found that certain pigments which are good conductors of electricity permitted the current to flow, and the galvanometer needle was deflected to quite an extent. On the other hand, in the case of pigments which are absolutely non-conductors of electricity, there was no movement of the needle. As would be expected, those pigments which caused deflection of the galvanometer, such as the carbonaceous group, were in the active stimulative class, while those which prevented the deflection of the galvanometer needle were in the inhibitive class. These results confirm Dr. Cushman's results regarding the nature of such pigments. Corrosion in structural steel in situ appears to be dependent largely upon what Dr. Thompson, in commenting on the work of Cushman, Walker and others, has aptly designated "auto-electrolysis"—that is, electrolysis due to currents set up between areas having different potentials in the material itself. These currents require the presence of an electrolyte to serve as a conductor and thus complete the electrical circuit. It thus appears probable that a paint film which, when moistened, becomes a good conductor of electricity, may serve as an active aid to corrosion through this physical quality alone.

CHAPTER III

Results of Inspection of Steel Test Fences

As explained in the "Preliminary Report on Steel Test Fences," in order to make a practical field test of the value of various pigments, it was decided by the Paint Manufacturers' Association to erect steel test fences at Atlantic City, upon which to paint out in oil medium all the pigments which previously had been tested out by so many investigators in aqueous medium.

Steel Test Fences for Practical Field Test of Value of Various Pigments

The work was carried out with the greatest care by the Scientific Section and was under the supervision of Committee E, on Preservative Coatings, and Committee U, on Iron and Steel, of the American Society for Testing Materials. The Master Painters' Association of Pennsylvania was also represented in the work.

In the front of this book will be found a chart of the fences, showing the placement of every panel and giving the formula of the paint applied thereon. This chart will be of considerable value to anyone desirous of making a personal investigation of the fence.

A recent inspection of the fences indicated that it was too early to make a report, but a few observations recently made, may not be out of place at this time.

Condition of White Lead, Zinc Oxide, Oxide of Iron Paints

It was found that the white lead and zinc oxide pigments appeared to have thus far given excellent protection to the steel and iron upon which they were painted. The pure white lead, however, has shown tendency to chalk, while in some cases the zinc oxide has shown tendency toward checking. The red iron oxides applied to the steel plates seemed to be in good condition, with the possible exception of Venetian red on which there seemed to be a very slight exudation or leaching out of the calcium sulphate contained in this pigment.

Condition of Carbonaceous Paints

An examination of the graphite, lamp black and carbon black films showed that it was too early to report on their value. These films are still intact and the color prevents close examination of the underlying surface. However, it was observed that wherever the plates, which were painted with these pigments, had been abraded to the least degree, very active corrosion had started, and appeared to be spreading underneath the paint coating.

Inhibitive Pigments Standing Well

The plates painted with red lead were in excellent condition, as were also those painted with zinc chromate and zinc-and-barium chromate. In the case of the plates painted with zinc chromate, several abrasions made at the time of erecting the fence disclosed the clean steel plate which had suffered practically no corrosion. This, presumably, is due to the fact that zinc chromate being slightly soluble had kept the abraded places in a passive state and prevented any rust forming thereon. The

Value of Chromium Pigments

plates painted with chromium resinate seem to be in excellent condition, and the high efficiency of this pigment as a water excluder may prove it to be a valuable ingredient of a protective paint coating.

Prime Coaters

The plates, which were primed with various inhibitive pigments and topped with the same second-coater, have not shown as yet any definite results which would indicate which pigment to use as a prime coating material.

Defects Observed on Coal Tar Paints

The plates, which were coated with red lead and second-coated with bitumen and coal tar paints disclosed a most marked alligatoring of the top coats, through which the red lead used as a prime coater could be distinctly seen. Unequal expansion of the two coats is probably responsible for this fault.

Marked Rust Acceleration on Plates Coated with Gypsum

Those plates painted with calcium sulphate (gypsum) showed the most marked corrosion, the plates showing a brown coating of oxide of iron working itself completely under the coating.

Natural and Artificial Barium Sulfate and Calcium Carbonate

It was noticed that calcium carbonate and barium sulphate, both in the precipitated form, as applied to the steel panels, exhibited considerable chalking, while calcium carbonate and barium sulphate in their natural state, as whiting and barytes respectively, were standing up much better, no chalking being evident. The precipitated forms of calcium carbonate and barium sulphate gave the greatest hiding power, being quite opaque, while the natural forms, were very transparent.

The several samples of steel which were exposed unpainted after having been pickled showed varied degrees of corrosion, but it is too early as yet to report upon these plates. However, those plates which were exposed unpainted, but having the mill scale showed more rapid corrosion and more pitting than those plates not having the mill scale; in fact some of these plates having the mill scale corroded in certain spots in an extremely rapid way, leaving certain areas with the mill scale unacted upon. The mill scale in this case would act as a surface upon which the hydrogen evolved during the electrolytic action which accompanies the process of corrosion could be catalyzed to form water, thus allowing the corrosion to proceed very rapidly. This bears out the statement of Dr. W. H. Walker, Prof. of Industrial Chemistry at the Mass. Inst. of Technology, regarding the function of oxygen in the corrosion of iron and the action of mill scale as a depolarizing surface.*

Rate of Corrosion on Various Unpainted Plates

*This recalls some recent work done by Dr. Walker in which he finds linseed oil to be, under certain conditions, an accelerator of corrosion. He found that when a steel or iron surface painted with linseed oil became abraded in any particular spot, corrosion would proceed more rapidly in the presence of the coating of oil than without the coating. This he ascribes to the fact that the hydrogen, which is evolved during the corrosion is removed immediately by the linseed oil, which (being an unsaturated hydrocarbon) has an enormous power of absorbing the hydrogen and acts very much in the same way as mill scale in destroying the "electrolytic double layer," so-called. In the event, however, of the linseed oil containing different pigments there is a marked difference in the ability of the linseed oil to remove the hydrogen with sufficient rapidity to accelerate corrosion.

Wherever an abrasion appeared upon the paint coatings of the various panels, different results were noted. In the case of panels which were painted with certain stimulative materials, abrasions showed progressive corrosion had proceeded and pitting was evident, while in the case of panels painted with high power inhibitive materials, the steel was in very good condition.

Scratching Plates to Observe Action of Oil Coatings

In order to give this new development in the study of the corrosion of iron a practical field test, each plate on the steel test fences has recently been scratched at the lower right hand corner, using the same instrument in each case. The painted surfaces being thus abraded, the progress of the corrosion will be carefully watched and most interesting data may be recorded later on as regards the value of each pigment in linseed oil in checking any accelerative action which may be exerted by the linseed oil.

CHAPTER IV

Excluding and Water-Resisting Properties of Paints

Besides considering the pigments as stimulators and inhibitors, a most careful study has been made by the Scientific Section as to the value of various pigments as excluders or moisture resisters.

Excluders and Water Shedders

An excluding paint is one that has the property of excluding and preventing the admission of moisture to the steel, thus depriving the steel of the moisture which is essential to corrosion. A water-shedding paint is one which has the property, because of certain physical characteristics, of shedding water, and plates painted with such paints often appear dry immediately after a rain storm. Pigments greasy and unctuous in nature make good water-shedding paints. They may or may not have excluding values.

Properties of Excluding Paints

The excluding properties of a paint coating are largely dependent upon the composition of the vehicle. It has been proved beyond doubt that a vehicle the interstices of which are filled up with fused gum is superior in its water excluding properties. Some excluders do not have the property of moisture shedding, and observations have been made of

several plates painted with natural excluding materials which did not shed water, but which were the most perfect water excluders. Ordinarily linseed oil, when painted out and dry, is neither an excluder nor a moisture resister, as the tackiness of the film will show after a rain storm. A peculiar blistering appearance is also shown on the surface, showing where rain drops have acted upon the vehicle and penetrated through, leaving the coating soft and pliable and sometimes raising many blisters thereon.

Water Shedders Not Always Permanent

Considerable value has been attached to certain protective coatings whose only real virtue was that of being able to resist the action of rain and water, but which would ultimately break down in a very rapid way, allowing deep penetration by the water. The water shedding pigments which we have mentioned as being greasy in nature or unctuous, serve sometimes, when made into paints, as good protective coatings for a time, but sooner or later fail completely in their object.

How Moisture Goes Through a Paint Film

It has often been asked, in what manner does water penetrate a paint coating? When the coating is comparatively new and the linoxyn intact, the water goes through probably in two ways: either by forming a solid solution with the linoxyn coating itself and becoming a part of the paint, or by diffusing through the linoxyn, which is really a porous membrane.

Thus it would appear that the use of dif-

ferent pigments would produce more or less permeable films, according to the proportion of space filled up in the vehicle.

Properties of Different Pigments in Retarding Moisture Penetration

That certain pigments do have the power of preventing to a certain extent more than others the admission of water through a paint coating, the following series of experiments seem to prove.

Films made of Paints Used on Steel Fences

A series of paint films were made from many of the pigments which were used in painting the Atlantic City test fence. These paints contained the pigment ground in two-thirds raw and one-third boiled oil, without drier, and the films were painted out in three-coat work, allowing ample time between each coat for proper drying. No method has yet been devised for securing paint films of absolutely the same thickness, but the greatest care was taken in making these films to have them all approximately the same thickness.

Arrangement of Tests

Small bottles, like that shown in the illustration, were half filled with concentrated sulphuric acid and paint films were hermetically sealed over the mouths with Canada balsam. These bottles, numbered, were then accurately weighed on delicate chemical balances and afterward exposed under a large bell jar, all at the same time. This bell jar was so fixed that it could be saturated with moisture and kept under constant temperature. At the end of a week the bottles were removed and carefully weighed again. The increase in weight indicated the amount of moisture which had pen-

etrated the film in each case and which was taken up by the sulphuric acid, by absorption.

Results of Moisture Absorption Tests

The test was kept up for forty-nine days, making weighings every seven days. The figures in the table indicate the amount, in grams, of moisture taken up. The pigments

"MOISTURE EXPERIMENTS"

FIGURES GIVEN EXPRESS GAIN IN WEIGHT, *e. g.*, WATER ABSORBED

	7 days	14 days	21 days	28 days	35 days	49 days
Iron Oxides (with 2% Zinc Chromate and 2% Chrome Resinate)	0.032	0.048	0.072	0.092	0.110	.140
Dutch White Lead	0.040	0.078	0.111	0.162	0.187	.264
White Lead and Zinc Oxide	0.043	0.081	0.115	0.163	0.192	.266
China Clay	0.044	0.086	0.122	0.182	0.219	.317
Whiting	0.044	0.079	0.114	0.167	0.197	.277
Zinc Oxide, Barytes and Blanc Fixe	0.048	0.092	0.125	0.183	0.190	.290
Zinc Lead White	0.049	0.095	0.130	0.181	0.211	.284
Red Lead	0.049	0.092	0.130	0.187	0.215	.295
Basic Sulphate-White Lead	0.049	0.092	0.128	0.185	0.213	.292
Zinc Oxide and Whiting	0.060	0.110	0.156	0.221	0.256	.352
Zinc Chromate	0.064	0.121	0.176	0.270	0.298	.417
Barytes and Zinc Oxide	0.064	0.118	0.169	0.240	0.278	.386
Zinc Oxide	0.065	0.122	0.172	0.244	0.285	.391
Calcium Sulphate	0.066	0.140	0.212	0.313	0.377	.555
American Vermilion	0.069	0.140	0.202	0.311	0.349	.501
White Lead, Barytes and Blanc Fixe	0.074	0.137	0.200	0.294	0.344	.490
Barytes	0.074	0.138	0.202	0.298	0.336	.466
Willow Charcoal	0.077	0.154	0.236	0.378	0.459	.694
Lithopone	0.083	0.156	0.228	0.332	0.380	.550
Carbon Black	0.084	0.168	0.250	0.391	0.448	.654
Lead and Zinc Chromate	0.086	0.161	0.226	0.319	0.369	.497
Chinese Blue Stimulative	0.092	0.185	0.276	0.405	0.470	.671
Venetian Red	0.093	0.190	0.279	0.418	0.508	.770
Natural Graphite	0.104	0.223	0.350	0.539	0.632	.951
Medium Chrome Yellow	0.106	0.207	0.300	0.429	0.505	.725
Bright Red Oxide	0.116	0.240	0.365	0.548	0.662	.976
Barium and Zinc Chromate	0.116	0.211	0.298	0.430	0.481	.660
Ultramarine	0.119	0.230	0.336	0.484	0.578	.814
Prussian Blue Inhibitive	0.125	0.246	0.361	0.521	0.619	.733
Raw Linseed Oil	0.143	0.300	0.449	0.679	0.803	1.201
Lampblack	0.199	0.411	0.641	1.033	1.234	1.873
Blanc Fixe	0.210	0.472	0.744	1.144	1.414	1.944

Carried out by H. A. Gardner and Zoltan de Horvath

have been arranged with regard to the most perfect excluders at the top, followed by those which are less efficient as excluders. As will be noted in the table, the tests all the way through were confirmed at each weighing. At the head of the list stands iron oxide, which contains chromium resinate in small proportion. It will be found by careful observation of the list of pigments in the table that iron oxide by itself falls near the middle, but by the addition of 2 per cent. of chromium resinate, which acts as a gum to seal up the interstices of the pigment, this pigment has been rendered the most excellent water excluder that we have.

Practical, as well as laboratory, tests have brought out the new information which is presented to you, and a study of the tables contained in this book will doubtless prove of value to all interested in paints for the protection of iron and steel.

SUPPLEMENT

The steel wire fences erected in Pittsburg, under the direction of Dr. Cushman, and painted by the Scientific Section, are showing some interesting results. The cut shows a section of wire painted with a stimulative carbonaceous paint. The marked corrosion going on seems to indicate that the most inhibitive paints only should be used for painting iron and steel.

A further description of the steel wire panels may be found in Bulletin No. 35, by Dr. Cushman, of the Office of Public Roads, U. S. Dept. of Agriculture.

Section of wire painted with a stimulative carbonaceons paint

A Paint Catechism for Paint Men.

x x

Comprising terse practical definitions of paint materials and answers to the questions met in the sale and use of paints.

COMPILED BY

G. B. HECKEL,

EDITOR OF

DRUGS, OILS & PAINTS

634 and 636 The Bourse
Philadelphia, Pa.

PRICE 25 CENTS.

Contents,

INTRODUCTION.

The compiler of the following questions and answers claims no originality in subject or substance.

It has seemed desirable that sellers of paint should have available, in compact and convenient form, the technical knowledge of their specialty which has been accumulating during the past half century. This "Paint Catechism" is, therefore, a compendium of such information, gathered from many sources, and condensed for quick reference.

Where actual quotation has been made, the authority is given; but those definitions for which no authority is cited, while in no case original except as to language, must be credited to the writings of paint chemists and technical authorities in general.

It is hoped that the booklet may prove a real convenience for those for whose use it is intended.

1. *What is paint?*

"Any liquid or semi-liquid substance applied to any metallic, wooden or other surface to protect it from corrosion or decay, or to give color or gloss, or all of these qualities, to it."—*Wood.* More properly speaking, paint is a mixture of opaque or semi-opaque substances (pigments) with liquids, capable of application to surfaces by means of a brush or a painting machine, or by dipping, and of forming an adhesive coating thereon.

2. *What is the purpose of paint?*

To protect or to beautify surfaces, or to perform both offices. Paint is also valuable as a sanitary agent.

3. *What is house paint?*

House paint is paint designed to preserve and to beautify the surfaces of materials used in the construction of buildings.

4. *What is the best house paint?*

That paint which most completely performs the offices named.

5. *What are the materials used in manufacturing house paints?*

Pigments, drying oils, volatile oils or thinners, driers or "Japans" and varnishes.

6. *How may these pigments be divided?*

Into white bases, inert pigments, natural earth colors, chemical colors, pigment lakes, etc.

7. *Name the white bases.*

Oxide of zinc, basic carbonate of lead or corroded white lead, basic oxy-sulphate of lead (or sublimed white lead), zinc-lead, leaded zincs, and

lithopone; together with certain inert or sub-pigments (described herein under their proper titles.)

8. *What is oxide of zinc?*

Oxide of zinc is a combination of one atom of metallic zinc with one atom of oxygen. It is produced by two methods, one known as the French and the other as the American process. In the French process metallic zinc is burned in a current of air and the product of combustion, oxide of zinc, is collected in closed chambers. In the American process the ores of zinc mixed with finely powdered anthracite coal are burned in a closed furnace with perforated grate bars, and the resultant oxide of zinc, after passing through a series of cooling flues, is collected in fabric bags.

9. *What are the characteristics of oxide of zinc?*

In texture it is the finest of all white pigments and in color the whitest. A pound of dry oxide of zinc occupies about 50.77 cubic inches, while a pound of corroded white lead in the same condition occupies only 14.69 cubic inches. In consequence of its extreme fineness it requires more oil than any other white pigment to fit it for use with a brush. In one hundred pounds of zinc oxide paint ready for use there are about 46 lbs. of oil and 54 lbs. of pigment, while the proportions in a corroded white lead paint of similar consistency are about 76 lbs. of pigment to 34 lbs. of oil. Oxide of zinc is unaffected by any gases present in the atmosphere, has no effect upon any pigment with which it may be mixed, and is non-poisonous.

10. *What is corroded white lead?*

It is a compound of metallic lead with carbonic acid gas, oxygen and the elements of water. It is usually described as a combination of hydrated lead oxide with lead carbonate, in the pro-

portion of about two parts of the latter to one part of the former, though the variations from these proportions are extreme. Corroded white lead having the theoretically correct composition is very opaque and dense, and though not so white as oxide of zinc is quite white. An excess of either chemical constituent impairs its good qualities and its color. It is prepared in this country by four processes known as the "old Dutch" or "stack" process, the cylinder or "quick" process, an American modification of the Dahl process, and a mild acidless process.

11. *What is old Dutch Process White Lead?*

The process generally known by that name is an English modification of the original Dutch process. The process as used in this country is, in outline, as follows:

Metallic lead is melted and cast into perforated disks, called buckles, about six inches in diameter, which are put into pots containing about one pint of dilute acetic acid. These are placed in rooms holding several layers, or tiers, 600 to 1000 pots each. The pots are covered with boards and layers of tan-bark, placed between each tier. The rooms, technically called "stacks," are kept closed from three to four months. During this period the heat and the carbonic acid gas generated by fermentation of the tan, together with the acid vapors, combine to corrode the lead more or less completely, into a white flaky substance.

This, after it is crushed, screened, floated, ground in water and dried, forms the white lead of commerce, and is either sold in the dry state to paint and color manufacturers, or ground in linseed oil and sold for general painting purposes.

White lead thus produced is a compound of lead hydroxide and lead carbonate, often retaining a residue of acetic acid and more or less water. It is exceedingly variable in composition, nearly every sample analyzed showing different

proportions of the constituent components. Thus in four analyses reported by Prof. Hurst the proportion of carbonate ranged from 63.35 per cent. to 72.15 per cent.; that of the hydroxide from 25.19 to 36.14; and that of the moisture, from 0.42 to nothing. Prof. Church gives the ideal proportion as 70 per cent. of the carbonate to 30 per cent. of the hydrate, but this exact proportion is very rarely attained in practice. Five different American brands of pure Old Dutch Process White Lead, analyzed a few years since by Mr. Convers, proved to be constituted as follows:

	I	II	III	IV	V
Lead carbonate	85.32	79.37	78.58	77.98	69.96
Lead hydrate	14.83	19.80	20.11	20.60	30.19
Lead oxide			1.48	1.48	
Water	.03	.21			.07

The samples analyzed were dry leads and not the product in oil as sold to the consumer. The latter, especially when mixed without drying, as in the pulp process, will generally show a higher per centage of moisture, while acetic acid, tan bark, and uncorroded particles of lead, left by imperfect grinding and washing, are not rare. Church reports as high as eleven per cent. of lead acetate in flake white.

This, the ordinary white lead of commerce, is a heavy, opaque material, ranging in color from yellowish white (cream color) to grayish white; indeed, it seldom happens that two separate corrosions yield precisely the same shade or tone. White lead combines readily with linseed oil, works easily under the brush and increases the drying properties of linseed oil.

12. *What is Cylinder or "Quick Process" White Lead?*

In this process the melted lead is blown into fine granules by means of a jet of superheated steam. This powdered lead is charged into large, slowly revolving wooden cylinders or drums,

moistened with dilute acetic acid and subjected during several days to the action of air and carbonic acid derived from burning coke. The subsequent procedure resembles closely the methods of the old Dutch process.

The white lead produced is generally finer, whiter and more uniform than Dutch process white lead. Chemically it resembles the latter very closely, and is essentially the same.

13. *What is Dahl Process White Lead?*

In the modified Dahl process the metallic lead is first reduced to a fluffy or feathery condition. It is then placed in stationary tanks and by the action of dilute acetic acid, converted into a basic acetate of lead. The passage of a stream of carbonic acid gas through this solution precipitates the lead in the form of the basic carbonate (white lead). Washing, drying and grinding follow, as in other processes. The lead produced in this manner is exceptionally white, fine and uniform, and the particles are amorphous and not crystalline as in other precipitation processes. Owing to its fineness it requires more oil in grinding than other leads, exceeding "quick process" lead in this respect as the latter exceeds "stack" lead. The obscuring power or opacity of precipitated leads is generally lower than that of corroded leads.

14. *What is "Mild Process" White Lead?*

"The unique feature in this new process is that neither acid nor alkali is used—the conversion from pig lead to the basic carbonate being effected entirely by the successive action of moisture, air and carbon-dioxide gas. To this must be added the perfect control which the operator has in all stages of its manufacture.

"In brief outline the proceeding is as follows: Pig lead is melted by means of a specially designed machine and subjected to a blast of superheated steam, which reduces the metal to its

finest possible state of subdivision. This process partly hydrates and oxidizes the comminuted lead which passes thence into cylinders fitted with agitators and containing water through which a current of air is passed. The sub-hydroxide of lead is here further oxidized into lead hydroxide which is then treated in other cylinders containing water with a stream of purified carbon-dioxide gas which converts it into basic white lead of ideal composition, after which the completed product goes to specially designed drying beds."

15. *What are the characteristics of "Mild Process" White Lead?*

"Absolute uniformity; freedom from acids, alkalies and all impurities; extreme fineness, crystalline matter being entirely absent, whiteness and normal composition."

16. *What are the characteristics of Basic Carbonate White Lead?*

"It is scarcely necessary to point out that as white lead is made by many processes, it must necessarily vary in composition; indeed, the white leads yielded by the same process do not always have the same composition."—*Hurst.*

White lead is the most opaque of white pigments, a fact due largely to the small proportion of liquid required to reduce it to painting consistency; its spreading power, however, is correspondingly small. The lead hydrate contained in it unites with the acids of linseed oil to form a lead soap, which, while improving its brushing qualities, reduces its durability. It changes into the black sulphide of lead on exposure to sulphuretted hydrogen gas, and as this gas is almost universally present in the atmosphere, pure white lead seldom retains its original color. While a useful and valuable pigment on account of its opacity and working qualities, it is also a treacherous pigment because of its irregularity of composition, its deficient durability and its sensitive-

ness to atmospheric agencies. The durability of a good white lead paint will be about three years, but in the meanwhile the paint will have disintegrated on the surface and begun to wear off in the form of a fine powder ("chalking") or to come away in minute flakes ("scaling"). The powder and the scales as well as the dust arising therefrom are poisonous.

Another technical defect of white lead, as generally used, is that it is sold in the form of a very thick paste containing only about ten per cent. of oil. The purchaser adds the necessary liquids to fit it for use, stirring the mixture with a paddle. Uniform consistency is not obtainable in this way, and the paint produced is inferior.

17. *What is sublimed White Lead or Oxy-sulphate of Lead?*

"This product is so named because it is obtained by a sublimation process (from lead sulphide ores by a process analagous to that used to produce American zinc oxide.) The product is obtained directly as a very fine, impalpable white powder, without grinding. Chemically it is different from ordinary white lead, being apparently a basic sulphate of lead and * * * has approximately the following constitution:

Lead Sulphate, ...	75	per cent.
Lead Oxide	20	" "
Zinc Oxide	5	" "

"It exceeds in the fineness of the particles the ordinary grades of white lead and is at least equal to them in whiteness, body, covering power and wearing qualities. It differs from ordinary white leads in being non-poisonous and resists the blackening action of the sulphur compounds of sewer gas and of fuel gases to a much greater degree."—*Ladd.*

"The lead sulphate and lead oxide are chemically combined in sublimed white lead, forming

the true basic sulphate. This chemical combination of the sulphate and oxide into the basic compound explains the high degree of opacity which this pigment possesses. Its physical structure is entirely different from the ordinary lead sulphate, which has no pigment value. The zinc oxide present is caused by the presence of a small amount of zinc in the raw material used in its manufacture."—*Hughes.*

18. *What are the characteristics of Sublimed White Lead?*

"Like all pigments produced by sublimation processes, sublimed lead possesses in its ultimate particles a fineness far superior to that of pigments otherwise produced. On account of the extreme fineness of its particles it does not settle out of liquid mixtures. Being an oxy-sulphate it resists the discoloring action of hydrogen sulphide and other harmful gases in the atmosphere longer than does any other lead pigment. It is uniform in composition, is non-poisonous, and has no destructive effect on the paint vehicle. Expert paint manufacturers early recognized these characteristics and the paint manufacturing industry consumes practically the entire production."

19. *What is Zinc-Lead?*

"This pigment which has made its appearance within the last few years (fifteen or twenty) and which is practically unknown to the general public, is prepared from low grade zinc-lead ores which also usually carry small quantities of copper, silver and gold, the latter metals being exhausted after the removal of the zinc and lead. As prepared it is apparently a molecular combination of zinc oxide, lead sulphate and small proportions of lead carbonate and oxide. The combination, if it may be so termed, being affected at a high temperature, while the metals are in the form of vapor, the union is far more inti-

mate than would be obtained by grinding together the separate component pigments.

"In physical appearance the zinc-lead whites closely resemble a good grade of zinc oxide, but their specific gravity is higher and their density greater. This difference becomes more noticeable on grinding with oil, the proportion of oil taken up being much nearer the figure for Dutch process white lead than to that for zinc oxide. The density or obscuring power of the resultant paint places it in the lead rather than the zinc class. The chief objections made to it are that it is not always uniform in composition or color. An average of a large number of analyses gives it the following composition:

Lead sulphate	48.10
Lead carbonate	0.50
Lead oxide	0.60
Zinc oxide	50.50
Zinc sulphate	0.30"

—*Ladd.*

It remains to be added that the process and methods have been so standardized that the color and composition are now practically uniform.

20. *What are the characteristics of Zinc-Lead White?*

It is very fine, amorphous and uniform in the size of its particles; remains well in suspension; has a high spreading power; is durable and has little or no effect on any color with which it may be combined. In whiteness it is inferior to oxide of zinc and is, therefore, more widely employed in the darker tints and shades than in white paints or delicate tints. It is a useful and acceptable modern white pigment.

21. *What is Lithopone?*

Lithopone is a combination of precipitated zinc sulphide and barium sulphate (blanc fixe′ or "permanent white"). It is produced by the simul-

taneous reaction on one another of a solution of zinc sulphate and barium sulphide, the two chemicals in solution being in the correct combining proportions. The two substitutive products being formed and precipitated simultaneously, the union is very intimate. The process is often completed by heating and dropping suddenly in cold water. The product is very fine, white, and amorphous, and if properly made has excellent body and most valuable properties as a pigment, though most varieties of it are inadmissible in connection with lead pigments, on account of the susceptibility of the latter to darkening from sulphide combinations. For this reason it should not be used with oils containing a lead dryer. It finds extensive use in linoleum and shade-cloth manufacture and in enamel paints.

"When the material first appeared we examined it and it seemed to be the thing we were hunting for, something that was free from the objections to white lead and zinc white. * * * Experiments with it seem to indicate that it has covering power, body, working qualities and chemical inertness."—*Dudley.*

22. *What are the characteristics of Lithopone?*

Fineness, whiteness, body and opacity. "As an interior white, a first coat white, a ready mixed flat paint for a surface, or as a pigment in the lighter shades for floor paints, lithopone cannot be excelled for its body durability, hardness, fineness of grain, and ease of application. * * * The paint chemist should be permitted to decide when its value is the greatest. As a marine paint, either as a first coat or for making neutral whites where other whites would be necessary, it is found to outlast both zinc oxide and lead carbonate."—*Toch.*

23. *What are leaded Zincs?*

Oxides of zinc produced from western ores

which contain a certain proportion of lead sulphide ores. In the process of manufacture the lead sulphide is transformed into lead sulphate (sublimed white lead) and molecularly united with the zinc oxide. They are made with definite percentages of lead sulphate, ranging from about six to about twenty per cent., according to the purposes for which they are to be used. They resemble zinc-lead in composition, except that the proportion of the lead component is lower and the color generally whiter.

24. *What are the characteristics of Leaded Zinc?*

In fineness they are similar to other zinc oxides, in whiteness slightly inferior; their opacity is measurably greater on account of the contained lead sulphate. All western zincs contain some lead. "The zinc oxides made from western ores are slightly more permanent than those made from New Jersey ores, and as paint materials they possess the advantage of containing a larger quantity of lead sulphate."—*Toch.*

(As objection is frequently made to the minute fractional percentages sometimes present in zinc oxides, sublimed lead and zinc lead, we will ask,—)

25. *What is the effect of a small percentage of zinc sulphate in paint?*

"Nearly all zincs contain a small percentage of zinc sulphate. Much unnecessary trouble has been caused by the criticism against zinc sulphate. Where a paint contains moisture or where water is added in a very small amount to a heavy paint in order to prevent it from settling and not more than one per cent. of actual water (not water of hydration) is contained in the paint, zinc sulphate forms an excellent drier, particularly where it is desirable to make shades which

contain lamp black. The outcry against zinc sulphate is unwarranted because as much as five per cent. is used in making a patent drier. The amount of zinc sulphate, however, in most of the dry zinc pigments, decreases with age. * * * In the enamel paints, the presence of zinc sulphate is not a detriment, and in floor paints it might be considered as a slight advantage, for it aids in the drying and hardening."—*Toch.*

26. *What is an "inert pigment?"*

An inert pigment, properly speaking, is a chemically stable solid substance used as a component of paint—one which neither acts upon nor is acted upon by any other constituent. In this sense lamp black, graphite, carbon black, lead sulphate, smalts, etc., are inert pigments. Commonly, however, the term is applied to certain white or colorless substances added to white or colored paints for various technical purposes; especially to form the solid base on which staining colors are to be precipitated (as in the chemical lakes), to decrease the preponderance of chemically active pigments in the paint film (as where barytes or silica is added to basic carbonate white lead), to limit the excessive spreading power of a paint and thus to increase the thickness of the paint film, and to give it "tooth" (as where barytes or silica is added to zinc oxide paints).

The word "inert" has come to be used in connection with these pigments, because speaking generally and in a broad sense, they have the great advantage of being chemically stable or "inert" and not attacking the color or destroying the life of the vehicle as in the case of carbonate white lead. A more practical definition of "inert" or sub-pigments would be to state that they comprise a class of materials, each one of which possesses all of the valuable qualities of the true pigments less one or more qualities; as for instance, an inert pigment may possess covering

power, proper performance in the vehicle, absolute chemical stability or inertness, the maintenance of tone while reducing the strength of color, and yet while being deficient in great obscuring power or opacity as compared with white lead, for instance, this one drawback of inferior opacity will be more than offset by the peculiar qualities and advantages to the resulting paint which are entirely lacking in white lead and cannot be procured therefrom. Therefore the manufacturer can obtain all the necessary obscuring power by a proper proportion of true pigments and gain the peculiar and equally important advantages from the use in addition of such a subpigment.

27. *Which are the Inert Pigments in Common Use?*

Barium sulphate (Barytes, blanc fixe', permanent white), silica (silex, silicious earth), magnesium silicate (asbestus, asbestine pulp, talc), alumina (china clay, precipitated alumina, feldspar, kaolin) calcium sulphate (gypsum, terra alba) calcium carbonate (white mineral primer, Paris white, whiting, etc., etc.)

28. *What is Barium Sulphate, Barytes, Blanc Fixe' or Permanent White?*

Barium sulphate comes into paint manufacture under several forms dependent upon the method of preparation. Chemically it is a compound of an atom of the metal barium with one molecule of sulphuric acid, the former replacing the two atoms of hydrogen normally existing in the latter. It is found as a natural product in many parts of the world, and is a usual accompaniment of lead and zinc ores. The principal sources of supply in this country are in Missouri, Arkansas, Tennessee and Virginia.

The process of preparation consists essentially in grinding, removing impurities in an acid bath, and thorough washing. The finer grades are

further separated by water floating.

Precipitated barium sulphate, commonly known as blanc fixe' or "permanent white," is produced by precipitation of a soluble salt of barium from solution by means of a soluble sulphate. The barium sulphate is thrown down as an impalpable amorphous powder. The method is similar to that for lithopone, except that the substitution product here remains in solution.

In the preparation of several of the more permanent lakes, barium sulphate is thus precipitated simultaneously with the "striking" of the color, the union of base and "stainer" being thus made more intimate.

29. *What are the characteristics of Barium Sulphate?*

Its chief characteristic is extreme chemical stability. It neither reacts nor forms a chemical combination with any other material used in paint making, and remains absolutely unaffected by the elements or by any gases or vapors found in the atmosphere. It is, in the full meaning of the term, inert. It is also practically colorless when mixed with oil, hence has no modifying effect upon colors mixed with it. It is, therefore, an excellent medium for diluting highly colored pigments, without modifying their tone; for diluting chemically active pigments and thus prolonging the life of the oil in a paint film; for modifying the spreading power of many finely divided pigments, and for increasing the thickness of the individual paint film. It has been long used for admixture with lead and zinc in white paints, and this addition is held by practically all competent authorities to increase the durability of such paints.

30. *What is Silica (or Silex)?*

It is an oxide of the metal silicon, consisting of one atom of the latter with two atoms of oxy-

gen. It is very abundant in the earth's surface and exists in many forms, of which quartz, rock crystal, amethyst, quartz, sand, are the most familiar.

For use in paint manufacture it is prepared in several ways. By one method the transparent quartz rock is first disintegrated by heating and dropping into cold water, followed by grinding and bolting or water floating. In another fine quartz sand is similarly treated. Still another source of supply is the microscopic skeletons of diatoms found in the dry beds of geologic oceans. This grade is known as silicious earth, and requires only cleansing and bolting to fit it for use.

31. *What are the characteristics of silica?*

Hardness, inertness and colorlessness. In oil it has even less color than barytes. It is used for practically the same purposes as the latter, and very widely as the mineral base of paste wood fillers, for which purpose it is generally held to be unequalled. In paints it is held by some paint manufacturers to be superior to other inert pigments because of what is termed its "tooth," meaning the firmness with which it takes hold on a wood surface and adheres to other coats of paint.

32. *What is Magnesium Silicate?*

A complex combination of silicic acid with the metal magnesium and water of hydration. Serpentine, asbestus, jade and chrysolite are some of the forms under which it appears in nature. These forms are of great variety and shade into one another. The forms used in paints are generally modifications of talc and asbestus. For such use it is purified and ground to impalpable fineness.

33. *What are the characteristics of Magnesium Silicate?*

Inertness, fineness, unctuosity, lightness of gravity and a sort of physical "fluffiness," which

tends admirably to keep it in suspension. In its properties as an inert pigment it resembles those already considered, but physically it is very different. It is much softer, makes a very smooth paint and is held by those who use it to prevent "settling in the can" to a greater extent than the other pigments of this class. One of the large Eastern railway companies has used it for many years with great success as a component of its station paints.

34. *What is Alumina?*

An oxide of the metal aluminum, consisting of two atoms of the latter combined with three atoms of oxygen. In this form it occurs in nature as corundum, emery, ruby, sapphire, etc. Alum, which is a sulphate of alumina, under certain conditions precipitates a trihydrate of aluminum, which is a powerful absorbent of organic dyes. This fact is taken advantage of in dyeing fabrics and in the preparation of several of the lakes.

The silicate of aluminum—china, clay, kaolin and feldspar—is often incorrectly called "alumina" and hence is described here under this heading. These substances are complex hydrated silicates of alumina, (kaolin or china clay, being feldspar which has undergone decomposition by agelong action of the elements.) The former is taken from the earth, washed and floated. The latter is ground and bolted or floated to prepare it for use.

35. *What are the characteristics of Silicate of Alumina?*

Inertness, practical absence of color—though in this the clays are inferior to barytes and silica, while feldspar is about the same—impalpable fineness in the case of kaolin, appreciable "tooth" in the case of feldspar. Otherwise the material is comparable to the silicate of magnesium in its properties.

36. *What is Calcium Sulphate?*

The hydrated sulphate of the metal calcium, consisting of one atom of the latter combined with one molecule of sulphuric acid and two molecules of water of crystallization. When a part of this water is driven off by high heat the substance becomes "plaster of Paris," which again hardens on absorbing water. A similar phenomenon is familiar in Portland cement. Calcium sulphate in its native form is known as gypsum,—when transparent, as selenite.

For use in paints it is carefully ground, so as to avoid driving off the water of crystallization, and bolted.

The authorities of the Pennsylvania Railroad and some other lines prefer calcium sulphate to other inert pigments—on economic grounds alone, however—and require large percentages of it in their specification paints.

37. *What are the characteristics of Calcium Sulphate?*

Inertness, medium softness, colorlessness, and ease of manipulation. It is soluble in 500 parts of water; that is, one pound will be dissolved by about 63 gallons of water. This, however, seems to be of no practical significance when it is used in oil paints. If the hydration be complete, gypsum is as efficient as other inert pigments, and for some purposes would appear to be preferable. Dr. Dudley, of the Pennsylvania R. R., as above indicated, gives it full preference.

38. *What is Calcium Carbonate?*

A combination of the metal calcium with carbonic acid in the proportion of one molecule of the former with one of the latter. It is familiar in nature as marble, chalk (from which whiting is produced by grinding, washing and floating), Mexican onyx, crystalline calcite, etc. For use in paint it comes in the form of the finer

grades of whiting, Paris white, mineral primer, etc.

39. *What are the characteristics of Calcium Carbonate?*

Each of these forms of calcium carbonate has its own peculiarities. The finer qualities of chalk produced from ancient shell deposits, when finely washed and floated, produce a product known as "Paris white" or "bolted whiting." This is practically amorphous and is extremely fine, tends to hold pigments in suspension, neutralizes any free mineral acid in the oil or pigments (although inert to neutral linseed oil) spreads well and is of excellent value with heavy oxide pigments. Another type of calcium carbonate is white mineral primer. This has a definite structure but is ground extremely fine and floated. This structure gives it a certain "tooth" which makes it an excellent filler and shortener for retarding the excessive spread of zinc oxide. Both of these forms of calcium carbonate are found useful in paint, both as a protective durable coating and for chemical reasons, since it will completely neutralize any mineral acid remaining from the processes of manufacture in pigments or vehicles, Thus any residue of sulphuric acid remaining in linseed oil from the refining process, any traces of mineral acid remaining from bleaching barytes, any excess of sulphuric acid in the iron oxides, can be most safely and effectually neutralized by an addition of calcium carbonate to the paint. For this purpose the Pennsylvania R. R. specifications require the addition of a small percentage of this ingredient.

It is worthy of note that the old-time putty, which was made of linseed oil and calcium carbonate alone, has been known to endure without apparent deterioration, for half a century.

40. *What are natural Earth Colors?*

Colored compounds found as deposits in the

earth and utilized as pigments, either in their natural state after grinding and purification, or after further treatment, such as oxidation by burning, calcination, etc. The principal varieties are the mineral browns (Prince's mineral), ochres, umbers, siennas, natural iron oxides, mineral black, and a few allied substances. Of these Prince's mineral is a natural iron oxide in which the oxidation is completed by furnacing in a current of air; raw umber is a similar natural iron oxide containing manganese and burnt umber the same similarly treated. Raw sienna is an allied mineral and burnt sienna the same further oxidized by calcining.

Allied to these are the so-called oxides produced by grinding the natural iron oxides (haematites) from various localities. They range in color from a warm brown to a brilliant scarlet, dependent upon the composition of the original mineral and the degree of oxidation.

Similar highly colored products are produced by driving off the sulphuric acid and water from sulphate of iron (green vitriol). Venetian red, an allied product, is produced by precipitating the iron oxide of green vitriol from solution with lime water and afterwards oxidizing in a furnace. The resultant product is a close combination of iron oxide with calcium sulphate. Venetian reds of similar character are also produced by grinding high grade iron oxide with inert bases, such as calcium sulphate.

Ochres are hydrated iron oxides permeating a clay base. They are produced by agelong percolation of water through a body of iron ore into adjacent veins or beds of clay. They differ widely in color, tone and composition.

41. *What are Chemical Colors?*

Chemical colors are pigments produced by chemical action of one substance (usually in solution) upon another, resulting in the precipitation of a highly colored compound. Following are the

principal chemical colors in common use: The various Prussian or cyanide blues (Chinese blue, Antwerp blue, etc.), made by precipitation from the ferro-cynide or ferri-cyanide of potassium by a soluble salt of iron (Prussian blue is destroyed by lead carbonate.) The chrome or chromate yellows are made by precipitating a soluble lead salt by a soluble chromate, the resultant product being a lead chromate. The various shades (light, medium, deep, orange, etc.) are produced by precipitating with the chromate some modifying substance like lead sulphate or barium sulphate. There is also a very permanent zinc chrome in which the lead base is replaced by zinc.

Chrome or chromate greens are combinations of a specially prepared Prussian blue with chrome yellow, usually precipitated together and modified in the darker neutral shades by the type of chromate used. These greens in their pure state are unsatisfactory as to permanence, hence it is practically the universal custom to grind with them some inert protective pigment,—barium sulphate preferably—which diffuses and reduces the pigment without materially impairing its color or opacity. A high grade of commercially pure green, therefore, usually contains about 75 per cent. of barytes. These greens should never be used with a white base containing carbonate of lead, as the Prussian blue content will be bleached by it in the can. Oxide of zinc, oxy-sulphate of lead, or a leaded zinc should be used as the white base. Chromium oxide, the original "chrome green," is now but little used on account of its prohibitive cost and its dull tone. Where great permanence is required, as on railroad signals and the port-light boxes of vessels, it is still used to a limited extent.

Ultramarine and cobalt blue, English or Chinese vermilion, red lead and orange mineral, may also, in a certain sense, be termed chemical colors, in that they are the products of chemical transformation. The two blues are produced by a special

method of fusing together the components of lapis lazuli (the original ultramarine). Neither of these colors should be used with any other pigment or substance containing lead. White lead, chrome yellows, chrome greens and even oils containing lead driers are therefore debarred. Oxy-sulphate of lead does not act so quickly as the carbonate in discoloring the blue, but will act surely if slowly. The preferable white bases for these colors are oxide of zinc or sublimed lead, with or without the addition of inert pigments.

There are two true cobalt blues, of which one is familiar as "smalts." The other is a compound oxide of cobalt and alumina. It is more familiar as an artist's color than as a pigment for house paints. The quicksilver vermilions are a sulphide of mercury, produced either by sublimation or by a precipitation process. Their color is apparently due to the form of the particles, and gradually changes, on exposure, to the natural brown or black normal sulphide of mercury. They have been largely replaced by the so-called American vermilions and vermilionettes, the latter being really a form of lake and will be described under that heading.

American vermilion, sometimes designated as Chinese red, Persian scarlet and other names, was for many years in great demand owing to its permanency, but as it loses its brilliancy by the breaking of its crystals when milled, it is now largely replaced by the aniline scarlets which are classed among the fastest of the vermilionettes. In composition it is a basic chromate of lead, requiring special treatment to develop its color.

Red lead and orange mineral, as well as litharge, are oxides of lead. The first-named is produced by further oxidation of litharge at a low heat in an open furnace. Orange mineral is similarly produced by oxidation from the carbonate of lead instead of pig lead, and is therefore amorphous in structure and not crystalline This makes it much easier to hold in suspension,

while its color is lighter and more brilliant. These oxides form a cement with linseed oil and tend to harden in the can. Freshly mixed, they form an excellent protective coating for metal surfaces, but in time they produce "livery" paint. The addition of certain substances in small percentages delays this action. Fine grinding impairs their color.

42. *What are color lakes?*

A color or pigment lake is a pigment produced by the combination of a dye with a mineral base.

The varieties are exceedingly numerous. The number of such pigments among artists', lithographers' and carriage colors is, however, much larger than among house painting materials, since many of the lakes are transparent or translucent.

Some of the lakes are formed by simultaneous precipitation of the mineral base from solution with the coloring matter. The preferred base in such cases is usually alumina or barium sulphate.

The para reds, which have come into extensive use on account of their beauty, durability and body, are more brilliant and more permanent than quicksilver vermilion. Neither class of reds can be used with a white lead base without destroying the color.

43. *What are the Carbon Blacks?*

The carbon blacks are practically pure carbon. They comprise lamp black, a specially prepared soot from oil lamps; gas blacks (commonly known as "carbon blacks") from natural gas; and graphite, a natural product, now also produced artificially.

Bone-black, ivory black (a fine bone-black), drop black, vine black, etc., also come in this category. These, being produced by carbonizing animal and vegetable substances, contain proportions of inert mineral salts and are accordingly modified in tone.

44. *What are the characteristics of the Carbon Blacks?*

With the exception of those named in the last paragraph, they are practically pure carbons. They are, therefore, absolutely inert. Lamp blacks and gas blacks are amorphous, the particles are extremely fine and their specific gravity low; consequently they require a surprising preponderance of liquid to fit them for use. Their covering capacity in proportion to weight is enormous and their durability is a striking example of the durability of inert pigments in general when used in painting. Their tinting power is great. They are seldom used alone as pure color, it being deemed technically advisable to grind with them such a proportion of colorless inert pigment as will measurably increase the thickness of the paint film without perceptibly impairing its opacity.

Lamp black lettering on old signs has been frequently known to stand out in relief after the wood surrounding it has been deeply worn away by the elements.

Graphite, among the carbon pigments, stands apart, its unctuous quality, familiar in stove-polish and lead pencils, distinguishing it. It comes in two forms—flake and amorphous. It is as durable as the other carbons and like them, is frequently ground with silica or other colorless, inert pigments. Its chief use is in protective paints for metal surfaces.

The remaining carbon blacks are used principally as tinting colors only.

45. *What are the Drying Oils?*

Linseed oil, poppy seed oil, nut oil, China wood oil and sun-flower seed oil. The first-named is very extensively used, the second two in artists' colors and some special paints where extreme whiteness is essential, the fourth is coming into favor for certain lines of paint and varnish. The

last-named has been used in this country experimentally only.

To these should be added certain semi-drying oils, such as corn oil and cotton-seed oil.

46. *What are the characteristics of a drying oil?*

Drying oils have the peculiar property of absorbing oxygen and forming a tough elastic substance. They harden, (with the exception of China wood oil, which seems to "set" simultaneously throughout, like cement) from the surface inward. Certain metallic oxides and salts when incorporated with these oils by heat or otherwise, by acting apparently as carriers of oxygen, hasten the drying process. On exposure the hardening progresses slowly until the material finally crumbles and disintegrates. The added metallic salts, etc., are known as "driers," the oil in which such driers have been incorporated as "drying oils" and if incorporated by heat, as "boiled oils." A strongly concentrated drying oil thinned with a volatile oil (turpentine, benzine, etc.) is also known as "drier," and sometimes, especially if a gum or resin be added to it, as a "Japan drier."

47. *Why are drying oils used in Paint Manufacture?*

First, to give to the paint the necessary fluidity; secondly, to insure the uniform distribution of pigment on the surface; thirdly, to form a firmly adherent and coherent film of the proper character; and lastly, to produce in the paint the desired lustre.

48. *Why is linseed oil usually preferred for this use?*

First, because it is the most abundantly obtainable of all the drying oils, and on this account its use is very generally understood; secondly, because its cost is generally moderate in comparison with other drying oils; and thirdly,

because in our present state of knowledge the results obtained with it are more uniform than with other oils, whether used by the expert paint or varnish maker, the painter or the unskilled novice.

49. *Are the same proportions of "driers" used in all paints?*

No. Some pigments themselves act as "driers"—such in order of drying "strength" are red lead and the other lead oxides, lead carbonate, the iron oxide paints, of which the umbers are the "strongest," the chemical colors beginning with the chrome yellows. The carbon blacks, the lakes, the blues, zinc-oxide, zinc-lead, lead oxysulphate, lithopone have very little drying power—the carbon blacks none. In this the latter resemble the other inert pigments, of which alone calcium carbonate, which is not chemically inert, possesses drying properties. Ordinary white lead has moderately strong drying properties, differing in this respect according to its chemical constitution.

50. *For what purpose are driers added to Paint or to the Linseed Oil used therein?*

For convenience alone. In most circumstances it is desirable that paint shall dry within a reasonable time, to prevent the adhesion of dust and insects, to avoid the danger of soiling of person or clothes, to enable additional coats to be applied.

51. *Do driers improve the wearing qualities of paints?*

By no means. As the final destruction of the paint film is due to oxidation, anything which hastens oxidation shortens the life of the paint.

Therefore, the addition of "driers" and the proportion of drying pigments in a paint should be carefully limited to the practical necessities above indicated.

52. *Is China Wood Oil used in Paint Manufacture?*

Not so much as in varnish making; but it has some remarkably valuable properties which promise for it a growing use.

53. *Are petroleum oils other than benzine ever used in Paints?*

In rare instances, except where they occur as an adulterant of linseed oil sold to painters and consumers. In some special paints for the protection of metal surfaces, heavy petroleum oils are used to a limited extent to retard the hardening of the paint film. As the linseed oil used in such a combination requires special treatment, these oils should never be used except under expert supervision by the paint manufacturer.

54. *What are Volatile Oils or Thinners?*

Certain liquids which form a perfect solution with drying oils, and on exposure to the air, evaporate rapidly and more or less completely. They are turpentine, wood turpentine, benzine or naphtha, alcohol, benzole, etc. Of these the first two named are practically the only ones used in paint. Benzole and a few similar products are used in specialties like varnish removers, bronzing liquids, etc.

55. *What are the characteristics of the Volatile Oils?*

Of the two used in paint, turpentine is derived by distillation from the sap of pine trees, the residual product being rosin. Wood turpentine is distilled from pine stumps and roots. Benzine is that distillate from crude petroleum which has a gravity of from 60 to 72 degrees by the Baume′ hydrometer; the lighter products are gasolines, etc.; the heavier products, fuel oils, burning oils, lubricating oils, etc. The Texas petroleums, having an asphalt base, yield benzines of lower gravity and hence slower evaporation than the oils of the Ohio valley, etc. Tur-

pentine and benzine have each a characteristic odor. Both are solvents of oils, resins, etc. Of the two, turpentine evaporates the more slowly, but some of the benzines approach it very nearly in this respect. Turpentine in the retail and jobbing market is frequently adulterated with heavier, non-volatile petroleum oils, but benzine is never so adulterated. Benzine on evaporating leaves no residue and has no effect on the paint film. Turpentine, being a slight oxidizer, is thought to have some drying action and is also believed (because, while the benzine can all be recovered from paint by distillation, the turpentine cannot) to leave something in the paint film. If so, it would seem that this residue could be nothing except rosin.

56. *For what purpose are Volatile Oils added to Paint?*

For their mechanical effect alone. To facilitate the labor of spreading, to reduce excessive proportions of oil, to hasten the "setting" of the paint, to reduce the gloss of under coats and thus improve the adhesion of subsequent coats and to destroy gloss so as to leave a dull finish.

57. *Has Turpentine any advantage over Benzine for these purposes?*

Such advantages as it may have are largely dependent on its slower rate of evaporation. This advantage is reduced in the case of the heavier benzines, and with the rapid destruction of our pine forests the cost of turpentine promises soon to be prohibitive for use in anything except the most expensive varnishes. The only exception to this is in "flat work," for which benzine is not satisfactory. Wood-turpentine varies greatly in quality, dependent upon the method of manufacture. The better grades when properly refined are practically identical with sap-turpentine.

58. *What are Varnishes?*

Varnishes, as used in paint manufacture, are solutions of resins or of fossil gums in drying oils. Their principal application is in enamels and similar specialties.

59. *What are the characteristics of Varnishes?*

They yield a firmer, smoother and more lustrous coating than oil, and are capable of being rubbed to a finer finish. Some "Japans," as already stated, have the character of a varnish. Some pigments, of which zinc oxide is a conspicuous example, appear to form a tough elastic combination with the gum resins, entirely different from the compound formed with linseed oil. This property is utilized in the preparation of enamel paints.

60. *In view of what has been said, can there be a "standard" Formula for Paints?*

No. As may be inferred, it is possible with different formulas to produce practically the same results; hence any attempt to establish standard formulas merely tends to limit investigation and improvement; to throw the paint industry into the hands of a few producers of raw materials and to stifle competition as well in quality as in price.

61. *Is any standard possible for Paints?*

Yes; the standard of quality as determined by results.

62. *What is a Reasonable standard of Quality for House Paints?*

It is based on accumulated experience with the best grades of paints, and indicates the following as the requirements for a good paint under average conditions:

1. To cover upwards of 300 sq. ft., two coats.

2. To produce a surface that is neither too hard nor too soft.

3. To have an average life of four years.
4. To be durable as to color.
5. To leave a surface suitable for repainting.

63. *What is meant by covering upwards of 300 square feet two coats?*

These specifications all refer to paints applied to wood. This specification means that each gallon of paint, to be satisfactory, should cover properly with two coats upwards of 300 square feet of surface. The covering power of strictly pure white lead paint under duplicate conditions seldom exceeds 250 square feet.

64. *What is meant by producing a surface that is neither too hard nor too soft?*

A surface that is too hard is subject to abrasion, cracking and chipping off; a surface that is too soft is subject to removal by rubbing or scraping. This characteristic in extreme cases amounts to permanent stickiness; in another sense the phrase includes "chalking," which see.

65. *What is meant by having an average life of four years?*

That, under average conditions of surface, climate and exposure, repainting shall not become necessary for surface protection more than once every four years. In exceptional or favoring cases this life of a good paint may extend to ten or fifteen years. Except for uncontrollable circumstances it should not fall below three years. Strictly pure white lead paint, except in extraordinary circumstances, will not last over three years. It frequently perishes in less than half that time.

66. *What is meant by "durable as to color?"*

That within the period fixed as the average durability of the paint, there shall be no marked change in the original color of the paint beneath any surface deposit of soot, dust, etc.

Strictly pure white lead not only darkens on exposure to the gases of the atmosphere, but it has a bleaching or discoloring action upon many pigments in daily use, such as Prussian and Ultramarine blues, English and American vermilions and para-reds, etc. Even on many of the natural earth pigments it has a bleaching action.

67. *What is meant by "leaving a surface suitable for re-painting?"*

That when repainting becomes necessary the remainder of the old paint will present a practically unbroken surface and permit of firm adhesion of the new coating.

68. *How does Paint disappear from a surface?*
It may chalk, peel, scale, flake or wear away.

69. *What is chalking?*

Chalking is that quality (most characteristic of strictly pure white lead) which some paints have of disintegrating, falling into powder and dusting or washing from the surface irrespective of normal wear and tear. It is due to progressive chemical action between oil and pigment in the presence of oxygen, carbonic acid gas and moisture. The paint on a "chalking" surface will rub off on the clothing. Such paint has been included in a foregoing definition as "too soft."

70. *What is peeling?*

Peeling indicates an imperfect attachment of the paint film to the surface. The term sufficiently describes the action. Any paint may peel if applied to a damp, greasy or resinous surface. Peeling may also be caused by interior artificial heat, driving moisture outwards under the paint film; by capillary moisture rising into wood in contact with the earth, etc. Pure linseed oil paints are more liable to this defect than cheaper paints containing alkaline emulsions and water.

71. *What are scaling and flaking?*

The premature detachment of paint in small scales or larger flakes. A brittle paint, in the circumstances where a more elastic paint would peel, will scale or flake, according to its degree of brittleness.

72. *What is meant by wearing away?*

The normal wear of paint is both a chemical and a mechanical process. The action of atmospheric oxygen on linseed oil, as already stated, is progressive, from a tough elastic substance to a pulverulent mass. A coating of linseed oil alone disappears in this way. The addition of an inert, opaque pigment, obstructing the penetration of air and light, limits this action to the surface of the paint film. As the surface thus disintegrates, it is slowly and uniformly washed or worn away, exposing continually a fresh surface to the atmospheric attack, until the entire film is thus worn away. Thus while this normal wear is dependent upon external causes, chalking is due to a destructive chemical action between the components of the paint itself.

73. *Which is the most Desirable Mode of Disappearance?*

Naturally by normal wear; and it is one of the chief objects of the well informed paint chemist and paint manufacturer so to compound and prepare his products that they shall not chalk, scale, flake nor peel, but wear away normally from the surface.

74. *How is this accomplished?*

By maintaining a due chemical balance between pigments, oils, driers and other ingredients of the paint, as well as by a careful selection of the single ingredients themselves,—care for example, that the iron oxides contain no free sulphuric acid; that the linseed oil is prop-

erly ripened and settled and the free fatty acid content not abnormal; that proper allowances be made in composition for umbers with a high manganese content; that the chemical activity of the white lead selected be duly compensated for by some other ingredient, etc.

75. *In view of the foregoing facts, is it possible, or if possible, advisable, to prepare all tints with a white base of fixed composition?*

By no means. It will be understood, from what has been stated, that practically every tint or shade, if the ideal practice were followed, would require a separate formula and special treatment. But confining himself within rational practical limits, the enlightened paint manufacturer divides his tinting colors into groups with common characteristics and varies his white base and his formulas according to the group. Thus, the well-informed manufacturer may combine the vermilions, blues, para reds, etc., with zinc oxide, zinc-lead, lithopone, the inert pigments, but he will be very chary of combining any of them with a base containing carbonate of lead.

76. *What is the Cause of Blistering of Paint?*

Heat vaporizing underlying moisture. Only new paint is subject to this evil, unless the heat be excessive, and one paint appears to be as much subject to it as another. Excess of volatile oil prevents it. Incompletely dried lumber would seem to be the chief cause. It may be partially due to a chemical action of light and heat on the oil, segregating glycerine under the blisters, and partially to the expansion of the water in moist spots under the paint. The blisters often disappear in a short time, but the paint is detached from the surface and will scale away when the paint becomes brittle. They are merely a detached covering, not an adherent coating of paint.

77. *What is "Alligatoring?"*

An incomplete form of peeling, where the paint cracks into large segments, one end of the segment loosening and curling back from the surface, while the other end remains firmly attached, the surface remotely resembling the back of an alligator. When the alligatoring is fine and incomplete it is usually termed "checking."

78. *What is the cause of "Alligatoring?"*

Heavy coats of paint applied to unseasoned wood will alligator, especially if the paint be slow drying, tough and inelastic. Rosin drier in zinc paints is said by Toch to be the chief cause of the form known as "checking."

79. *What is the remedy?*

Scrape or burn the old paint off and repaint with thinner coats.

80. *How may chalking, peeling, flaking, alligatoring, etc., be avoided?*

By the selection of a properly prepared paint and its proper application to a surface in fit condition for painting.

81. *What is a properly prepared paint?*

A paint in which the ingredients are selected with due regard to their physical and chemical characteristics and thoroughly amalgamated into a homogeneous mixture, extremely fine grinding of the pigments being also essential.

82. *What is meant by the proper application of paint to a surface in fit condition for painting?*

The "proper application of paint" has reference to the consistency of the paint when applied, to the method of application, and to the time allowed to elapse between coats. The fitness of the surface for painting refers to its cleanliness, the nature as well as the condition of the wood,

and the state of the weather at the time of painting.

83. *How should the consistency of the paint be varied for different surfaces?*

The painter should understand these requirements. The priming coat, being the one on which the adhesion of the entire paint film depends, should be most carefully considered. It should be sufficiently liquid to penetrate every pore and irregularity of the surface, carrying with it particles of the pigment; but this fluidity must not be obtained at the cost of the future strength of the dried film. For the priming coat it is customary to add a quantity of oil and some turpentine or benzine. It is easy to overdo both. Only enough of the volatile thinner should be used to avoid a high gloss, to which subsequent coats will not readily adhere. Hard, unabsorbent woods require a thicker priming coat than spongy woods, such as poplar, soft pine, etc. Resinous woods, like yellow pine, again, require special treatment—a preliminary varnishing of knots and resinous spots with shellac, and subsequent priming with a fluid priming coat containing an excess of turpentine.

The second coat, which in many instances is also the finishing coat, should be tempered accordingly. If there are to be three coats, the paint should be slightly reduced with turpentine or benzine, so as to promote amalgamation with the priming coat, and to reduce the surface gloss. If it is to be the finishing coat, prepared paint of the average consistency can be used without reduction, but a very little turpentine is sometimes desirable to assist penetration and adhesion.

The third or finishing coat should usually be employed as it comes from the can. In the case of all coats, thorough, hard brushing is essential, and a round brush is always preferable to a flat brush. The failure of paint is frequently due to insufficient "elbow grease" with the brush.

Every coat of paint should be completely dry throughout before the next coat is applied; but it is a mistake to allow a priming coat to "weather" and become weakened before painting is continued.

Too much drier or japan, or cheap rosin japans are at the bottom of many paint failures. The manufacturer of a scientificially prepared paint will introduce the proper kind and quantity of driers into his formula, and none should be added in use.

84. *How is a fit condition of surface obtained?*

First, by delaying the application of the priming coat until the wood is thoroughly seasoned, unless seasoning has been properly attended to in the lumber; secondly, by seeing that the plaster on the inside of the building is completely dry before painting is begun on the outside. A new house should have been heated some weeks before it is painted. In an old house leaking spouts, etc., should be repaired and the adjacent wood allowed to dry thoroughly before re-painting. Thirdly, by avoiding the application of paint in moist weather or when the atmospheric moisture is high. Fourthly, by selecting a dry, mild season, as late spring or early fall, rather than a cold or hot season, as winter or mid-summer, for the work. Fifthly, by seeing that sappy or resinous spots in new lumber are properly treated before painting. Sixthly, by due care on old work that all loose paint and dust are removed by scraping, sand-papering, wire brushing, dusting, or if necessary, burning, before new paint is applied.

As a rule, it should always be remembered that two thin coats thoroughly brushed out, are better in most cases than one thick coat, and that repainting should never be delayed until the undercoats begin to loosen seriously.

85. *Can the Ordinary Property Owner Obtain Satisfactory Results with Prepared Paint by applying it himself?*

Only when conditions are favorable. In any case he should study carefully the directions on the can, and unless they are found to apply to his particular job, should consult either the manufacturer or a practical painter for fuller advice.

86. *Will a Chemical Analysis Determine the Quality of a Paint?*

No. To the expert paint chemist it will indicate whether the paint is scientifically compounded or not; but of the method of preparation, which is quite as important as composition, it will tell nothing. Only a thorough and exhaustive physical examination will tell this.

87. *Will the Blow-pipe Determine whether White Lead is good or bad?*

No. It will tell whether or not the material is a pure lead compound, but it will reveal nothing regarding its qualities as paint. The soluble salts of lead, such as the acetate or the nitrate, will yield metallic lead with the blow pipe more readily than will the carbonate, but when found in white lead they are very detrimental. On the other hand, the more stable white compounds of lead, such as the oxy-sulphate, though they may be pure lead compounds, will not reduce before the blow pipe without the use of a flux, except in the hands of a skilled operator.

88. *In View of all the Foregoing, What is the True Test of Paint Value?*

Service. The conditions, physical, chemical and technical governing the behavior of paint in any given case are so numerous and so obscure that it is hopeless for any one but an expert to attempt to comprehend them. House paint is designed to cover a wide range of conditions and

the better grades of prepared paints meet the average conditions with remarkable success. As between the many competing products, naturally, it is to the record of success rather than the composition of the paints that the consumer must look for enlightenment. There is always a reason—usually there are many reasons why a certain paint under certain conditions meets or fails to meet the requirements; but these reasons are usually obscure and technical and quite beyond the range of common knowledge. It may be taken as axiomatic that no paint obtains permanent popularity except on the basis of substantial merit. Success begets success, and nothing could be more conducive to increased sale of a given paint in any locality than the ocular demonstration of its value on painted buildings. It is this practical demonstration of superior convenience, economy and durability which has caused the consumption of prepared paint to expand from the humble beginnings of the industry in the late fifties, to its vast proportions of the present day.

Summary.

From the foregoing it will be seen that paint-manufacture is a progressive industry, dependent for success upon the knowledge and skill at the command of the manufacturer. The constant addition of new pigments and other materials to the list of available products and the keen competition between manufacturers insures progress. Sixty or seventy years ago there was but one white pigment generally available as a paint base. This was the carbonate of lead. The fact that its use precluded the use of many beautiful tinting colors, its well recognized sanitary inconveniences and its deficient durability, led not only to improvements in its handling and application, but also to its very general extension with inert pigments and to a diligent search for other white bases. This research has given

us oxide of zinc, sublimed white lead, zinc-lead, white and lithopone—all white pigments of great importance to the paint-consuming public. The field of paint production has thus been vastly extended, and the manufacturer has it within his power to vary his paint base as the conditions of use and the chemical nature of his tinting colors require.

The history of oxide of zinc in this connection is familiar. Since the middle of the last century its consumption has grown from nothing to something like 70,000 tons annually in the U. S. alone. The history of sublimed lead is another less familiar instance. The important and rapidly growing use of this pigment as one of the raw materials depended upon by the paint manufacturer for prepared paint is an excellent illustration of the advantages to the public at large resulting from the development of the paint industry, for the reason that sublimed white lead would probably not be in use to-day at all as a pigment, if its use had depended upon its being able to replace corroded lead in hand mixing; while, on the other hand, the paint manufacturer has been able to give the public the very real values and advantages of this pigment in the can of paint.

White lead,—that is the ordinary hydro-carbonate—owing to the long-continued use of the term to describe all kinds of white paints in paste form, has acquired an undue importance in the popular mind. While an extremely useful and valuable pigment, it is only one of many, and in a large proportion of the dark shades commonly used neither it nor any of the other white bases (excepting the inert pigments) has any place whatever. Furthermore, as has been shown it is absolutely misplaced and injurious in many of the popular tints produced from chemical colors,—the greens, blues, yellows, pinks, lavenders, salmons, delicate grays, etc., to cite only a few examples. In these cases and many others the

tint can be safely produced only with zinc oxide, sublimed white lead, zinc-lead or some similarly inactive white base. Even when white lead can be safely used, either by itself or in combination with the "limited palette" recommended by lead manufacturers, expert testimony strongly inclines to the opinion that its value for painting requirements is considerably enhanced by the addition of other white pigments and inert materials.

In the present state of our knowledge it is absolutely impossible to assert with authority that any given formula is "the best." We can say, however, that many formulas in common use are excellent and that it is surprising that from so great a variety we should obtain results so nearly identical. As before stated, the "best paint" is that which produces the most uniformly satisfactory results—for paint is bought to produce results, not to demonstrate technical theories.

In conclusion let us boldly and confidently assert that prepared paints are the sum of paint progress; that the hand of progress moves forward and not backward on the dial; and that the American people having once realized the economy, convenience and common sense of the sealed can with its completed product will not voluntarily return to the paint pot and paddle.

PRELIMINARY BULLETIN #20 C SECOND EDITION

PHYSICAL CHARACTERISTICS

OF A

PAINT COATING

By R. S. PERRY

Address Delivered Before the
Michigan Chapter, American Institute of Architects
1907

Scientific Section
Bureau of Promotion and Development
Paint Manufacturers' Association of the United States
3500 GRAYS FERRY ROAD, PHILADELPHIA

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PREFACE

ALTHOUGH this country has for some time led the world in the production of paints, its technical and scientific knowledge upon the subject of paint has not kept abreast with the practical experience possessed by the manufacturers.

During the past three years, however, the remarkable acquisition of knowledge resulting from investigations undertaken by our paint scientists, has placed the United States foremost in the technology as well as the production of painting materials.

This phenomenal advance probably dates back to the reading of this paper before the Michigan Chapter of the American Institute of Architects, in 1907. Its presentation stimulated most of the work that followed, being the pioneer to open up the pathway of investigations which have given us our new thought and new knowledge. That the architect and master painter have realized the scope and value of such work is evidenced by the demands for this paper, resulting in this second issue.

HENRY A. GARDNER

Director

Introductory Note

In this address, which was written in 1907, and delivered before the Michigan Chapter, American Institute of Architects, Mr. Perry first enunciated certain important scientific laws which are now generally recognized by paint technologists.

The circumstances under which the address was presented were unique, Mr. Perry being ill at the time and therefore unable to deliver the address. The duty therefore fell to Mr. A. H. Hooker and the writer—Mr. Hooker reading the address and the writer showing and commenting upon the illustrative lantern slides. Everyone concerned realized that new principles had been propounded in the technology of paint manufacture.

Perry has summarized these laws of paint technology as follows:

LAW No. 1—"The law of minimum voids to be observed in constructing a paint formula"—this law having already been accepted as mathematically correct and technically proved in the technology of concrete and cement.

Corrolary—The requisite thickness of a paint film together with the utmost attainable strength and impermeability can best be obtained by a properly proportioned blend of pigments of three or more determinate sizes.

LAW No. 2—The law of the flat arch in paint coatings—i. e. the fact that in studying the fundamental physical principles governing the strength and durability of a paint coating it is necessary to regard the coating as consisting of a series of flat arches, in which the pigment particles of largest characteristic size serve as the piers or supports for the flat arches of which the continuous film is composed.

Corrolary A—The strength and durability of a paint coating is determined by the strength and durability of the piers or supports (which consist of the characteristic pigment particles of largest size.)

Corrolary B—Owing to their inherent strength and durability the pigment particles of largest characteristic size which serve as supports for the paint coating should consist, in part at least, of chemically inert pigments, such as natural crystalline barium sulphate, calcium carbonate, magnesium silicate, etc.

Corrolary C—It follows directly that the thickness of a paint coating is determined by the particles of pigments having the largest characteristic size, even if that pigment be present only in moderate percentage. Upon this principle depends the comparatively great thickness of film and moderate spreading rate of paints composed of such pigments as basic carbonate—white lead, red lead, barytes, etc., and the strongly contrasted thinness of film and high spreading rate of paints composed of the sublimated pigments such as lamp black, zinc oxide, basic sulphate—white lead, zinc—lead white, leaded zinc, etc.

The recognition of these laws was an exercise of pure deduction.

Paint manufacturers, before Mr. Perry's announcement, were producing paints containing three or more pigments with particles of varying characteristic sizes; but their procedure was based largely on empirical knowledge, the result of accumulated experience, due to a conscientious endeavor to produce the highest type of paints for economic service. In the absence of any law to govern or to limit the use of the reinforcing pigments, inexperienced manufacturers had brought upon the market paints which were badly proportioned as to the several pigments or burdened beyond the limits of effectiveness with reinforcing pigments.

To all paint manufacturers Perry rendered a substantial service in deducing for them the laws set forth in his address. In the results following a recognition of these laws there was nothing new or startling, but Perry was the first to give the principles from which it can be determined in advance whether a paint formula will prove to be physically good or bad in practice.

As has been before stated, he was not the first to recognize the law governing minimum voids, but by that scientific use of the imagination which ~~Proctor~~ Tyndall so highly commends, he recognized, as by inspiration, the fundamental similarity existing between a film composed of solid particles cemented together by a semi-solid homogeneous menstruum and a layer of concrete composed of solid particles cemented together by a solid homogeneous medium. His application of the law permits the paint manufacturers to design a paint formula with full knowledge of the controlling conditions, so that it shall produce a coating neither too thick, and therefore uneconomical and subject to excessive internal strains, nor too thin, and thus weak and inefficient for protection.

That Mr. Perry's contention was well-founded, other paint technologists have since demonstrated; notably Mr. Wirt Tassin, in his microscopic studies of paint films in situ, and Prof. G. W. Thompson, who in his address to the Penna. Association of Master Painters at Reading, said:— "I want to agree with Mr. Perry * * * where he says that a pigment should be made up of particles of different sizes.

Mr. Perry also draws a further parallel between paint and concrete where he refers to the form of the reinforcing pigment particles and suggests that in paint coatings as in concrete a field can be found for the chemically inert pigments with rod-like or hair-like structure, to strengthen the film, just as the steel rods and iron mesh are used to reinforce concrete in structural work—a suggestion which, since the first publication of the address has been widely accepted as a practical aid in the manufacture of good paints.

G. B. HECKEL

PHYSICAL CHARACTERISTICS OF A PAINT COATING

By R. S. PERRY

This discussion will deal particularly with the dried layer of paint, or "the paint coating."

It will deal with the services that this paint coating should render as a durable protection in resisting the decay of the structural material it protects.

We may eliminate the question of the consistency of the liquid paint, the skill of the painter, the choice of coloring materials and the use of anything but linseed oil, with its thinners, and perhaps a little water as a vehicle, and confine ourselves to the subject of the white pigments, their choice and the proportions or percentages in which to combine them.

It should be emphasized that in this discussion the word "paint" will be used to refer to the liquid material—while the expression "paint coating" will be confined to the final layer of dried paint, which is the vital subject under examination.

What return then on the money invested will a coating of particular composition render in durability or life?

What service can be expected from paint coatings of particular composition in protecting the structural material and thus conserving the money invested in structural work?

The durability of the film of linseed oil holding the paint coating together is the life of the coating.

A word in explanation: When the liquid paint drys—as the painter says—or in chemical language, is oxidized to an apparently hard mass, the viscous linolein of the oil is converted into the rubber-like semi-solid linoxin. This accommodating elastic binder with its glossy surface, when supported by the proper pigments, acts as a seal, not only to protect the structure beneath from decay, but also its own inner mass from disintegration due to over-oxidation.

The properly prepared coating gradually wears away by surface oxidation and this surface wear

without internal disintegration gives a maximum life to the paint coating and consequently any combination of pigments that tends to shorten instead of prolong the surface life is to be deplored.

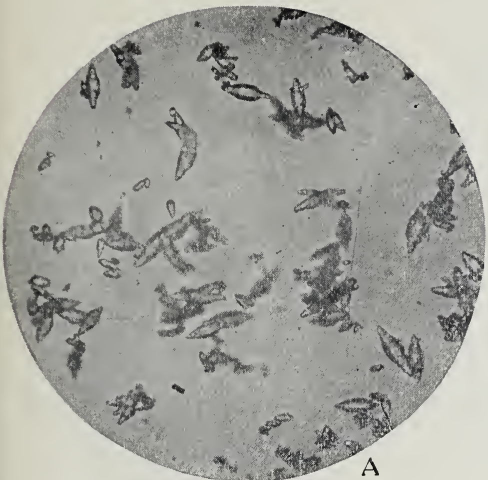
It is to be particularly noted that when this film of linolein becomes entirely oxidized it is a worthless, porous or chalky material, which, while perhaps apparently retaining original integrity, is admitting destructive agencies to the structure beneath. If the oil film in the paint coating chalks or pulverizes throughout its mass in advance of reasonable surface wear or oxidation, then the life of the paint coating is just so much shortened. In fact, this very property of scientific machine-made paint, to wear away by surface oxidation and not by internal disintegration, or chalking, is its strongest recommendation.

COMPARATIVE COSTS IN PAINTING

Each man to whom this is addressed knows well that of the total cost of a painting job the cost of the material, i. e., the paint, represents by far the smallest fraction when compared with the cost of application. Let us allow liberally—one-third the total cost for material and two-thirds for labor. Now consider for a minute what economies are possible by reason of the small proportion of cost that the paint material bears to the total cost if by carefully choosing a scientifically made paint we obtain longer life of the paint coating. The average cottage home contains 2400 square feet of surface; cost of paint used thereon amounts to about $12, the cost of labor about $24 and thus the total cost of painting amounts to about $36. Assume the life or durability of the average coating of pure white lead in oil to be four years. Experience shows that it will not average this, but usually begins chalking the second season.

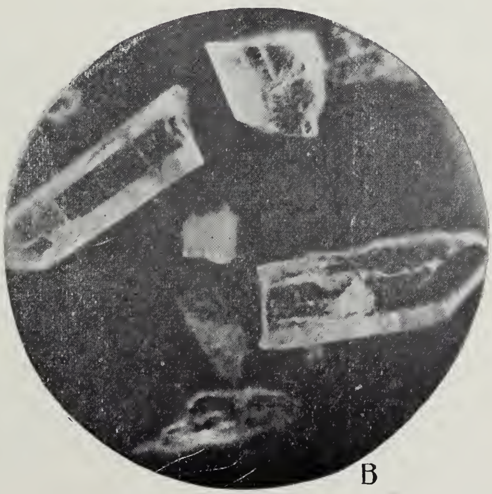
Taking these figures for argument we have for the total of $36 a cost of $9 per year investment for protection. If now by using one of the best grades of prepared paint we can extend the life of the coating to five years the owner can afford to pay five times nine or $45 for the five year job, as against $36 for the four year job.

PLATE I.



A

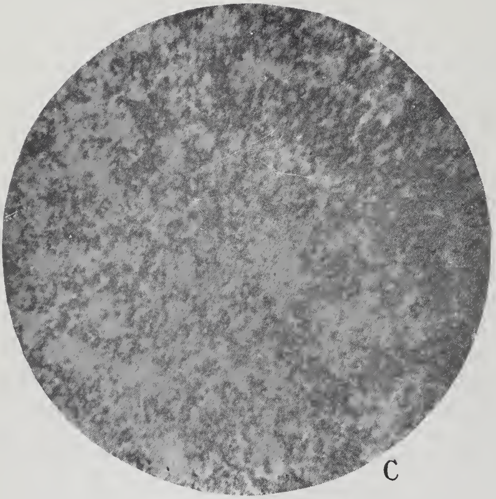
Crystals of Cerussite in Old Dutch Process White Lead.



B

Crystals of Cerussite in Old Dutch Process White Lead. (Greatly magnified.)

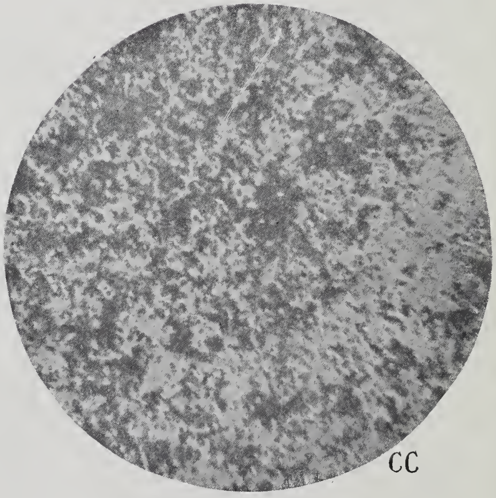
PLATE II.



C

Old Dutch Process White Lead magnified 250 Diameters.

(The pigment shows white in the plate.)

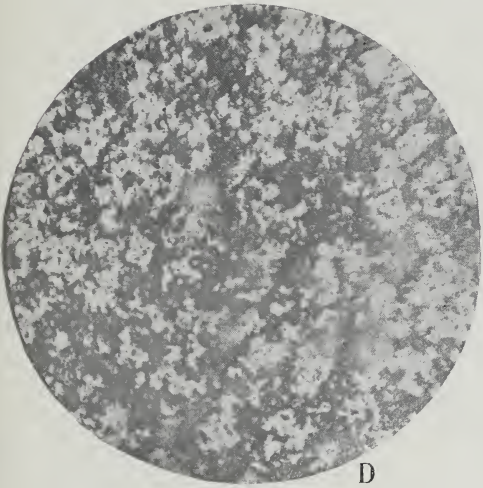


CC

Old Dutch Process White Lead. Magnified 250 Diameters.

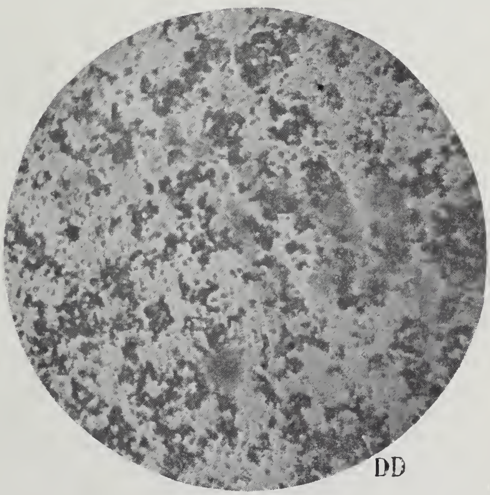
(By transmitted light. The pigment shows black in the plate.)

PLATE III.



D

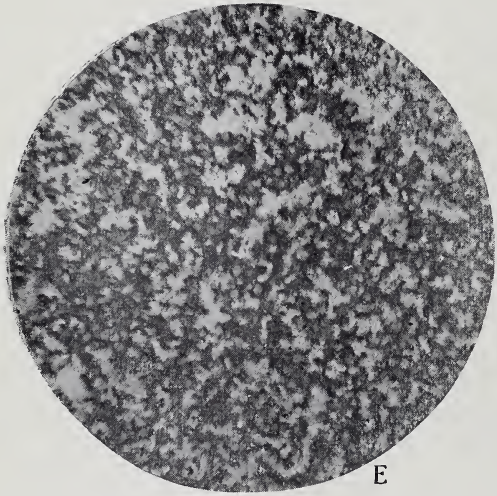
Quick Process White Lead. Magnified 250 Diameters. *(The pigment shows white.)*



DD

Quick Process White Lead. 250 Diameters. Same field as D., by transmitted light. *(The pigment shows black.)*

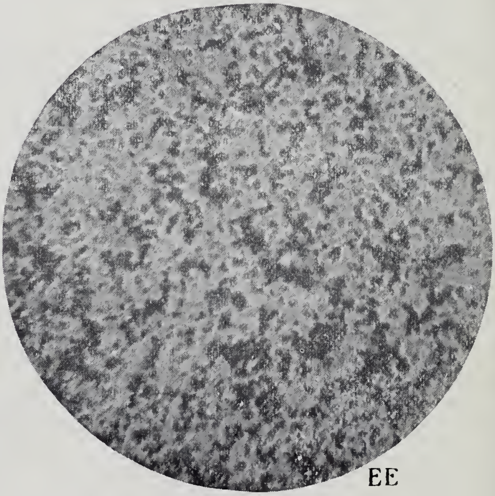
PLATE IV.



E

Lithophone. Magnified 250 Diameters.

(The Pigment shows white.)

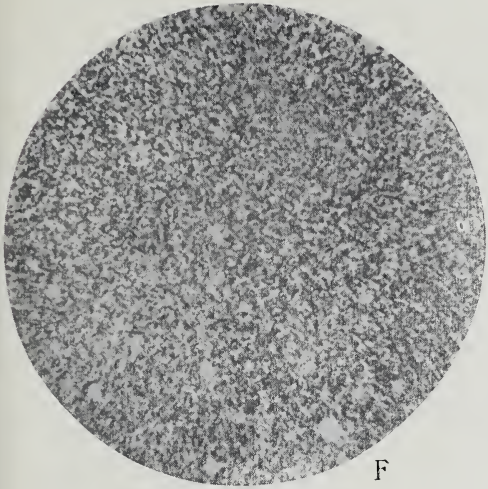


EE

Lithophone. Same field as Plate E, by transmitted light.

(The Pigment shows black.)

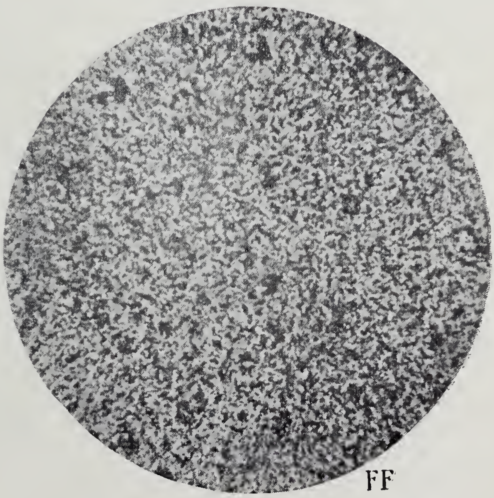
PLATE V.



F

Zinc Oxide. Magnified 250 Diam.

(The Pigment shows white.)

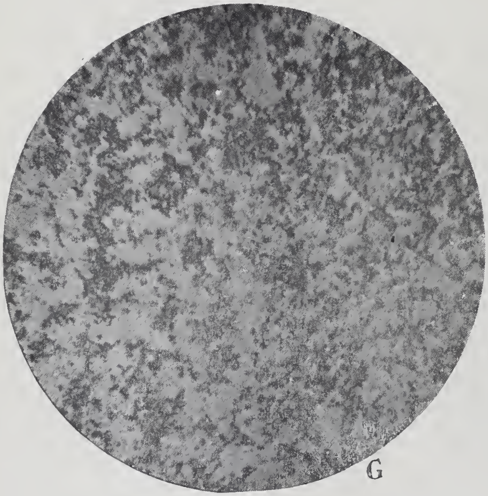


FF

Zinc Oxide. Same as F, by transmitted light.

(The Pigment shows black.)

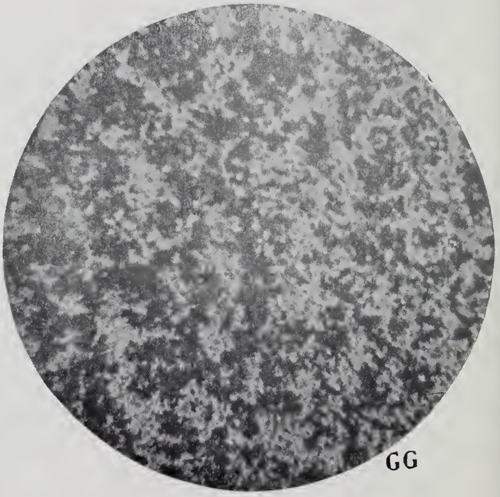
PLATE VI.



G

Zinc Lead. Magnified 250 Diam.

(The Pigment shows white.)



GG

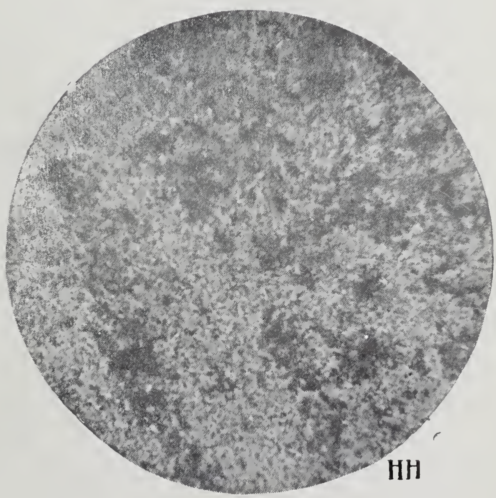
Zinc Lead. Same as G, by transmitted light.

(The Pigment shows black.)

PLATE VII.

H

Sublimed White Lead. Magnified 250 Diam.
(The Pigment shows white.)

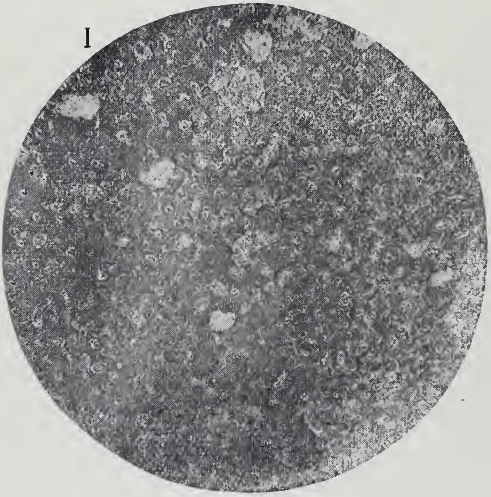


HH

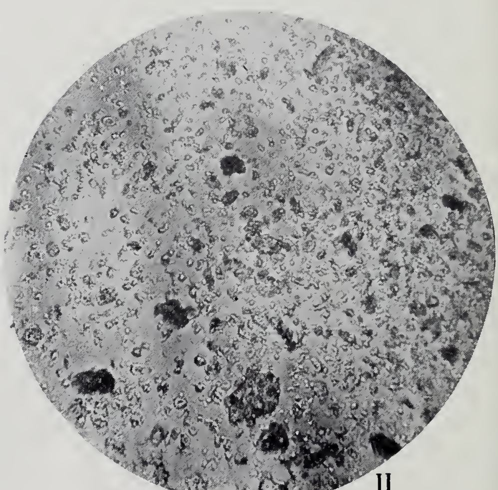
Sublimed White Lead. Same as H, by transmitted light.
(The Pigment shows black.)

PLATE VIII.

I



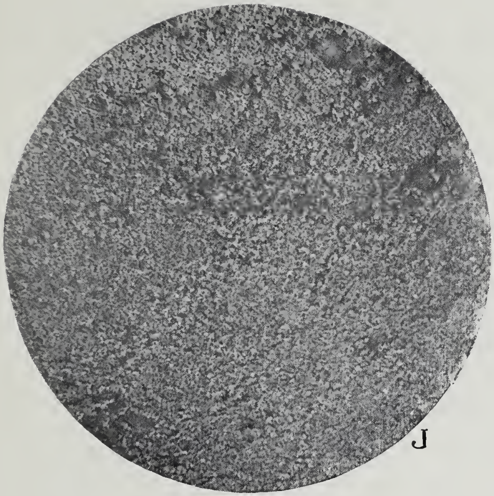
Calcium Carbonate (Whiting).
Mag. 250 Diam.
(The Pigment shows white.)



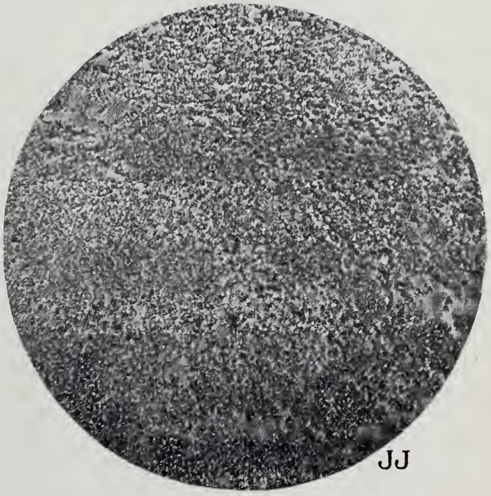
II

Calcium Carbonate. Same as
I, by transmitted light.
(The Pigment shows black.)

PLATE IX.

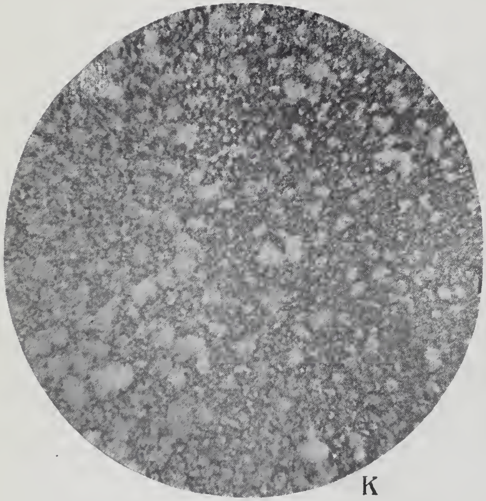


Blanc Fixe. Mag. 250 Diam.
(The Pigment shows white.)



Blanc Fixe. Same as J, by transmitted light.
(The Pigment shows black.)

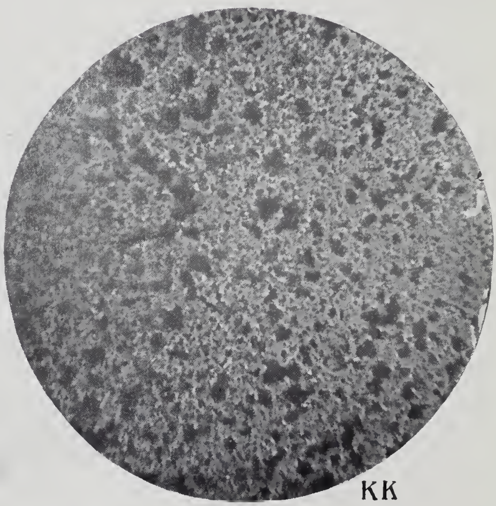
PLATE X.



K

Barium Carbonate. Mag. 250 Diam.

(The Pigment shows white.)

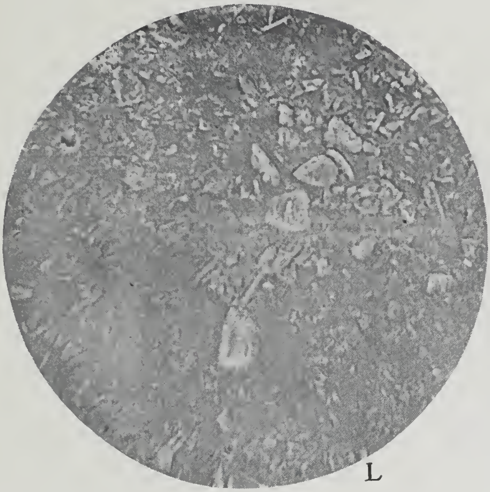


KK

Barium Carbonate. Same as K, by transmitted light.

(The Pigment shows black.)

PLATE XI.



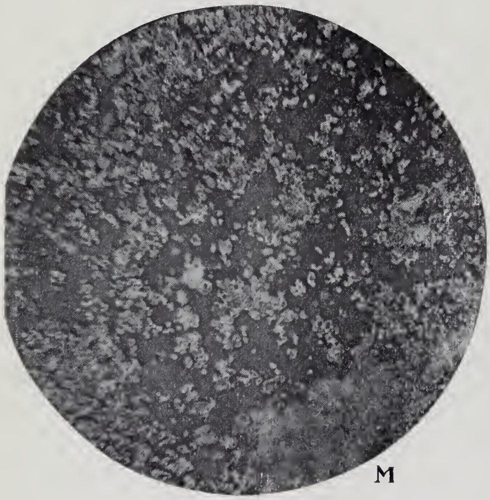
L

Silex. Mag. 250 Diam.
(The Pigment shows white.)

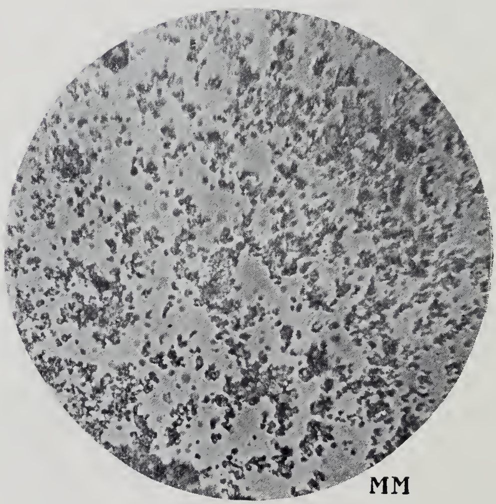
LL

Silex. Same as L, by transmitted light.
(The Pigment shows black.)

PLATE XII.

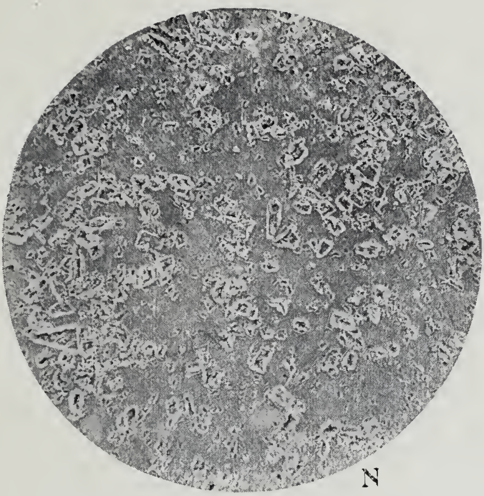


American Barytes. Mag. 250 Diam.
(The Pigment shows white.)



American Barytes. Same as M. by transmitted light.
(The Pigment shows black.)

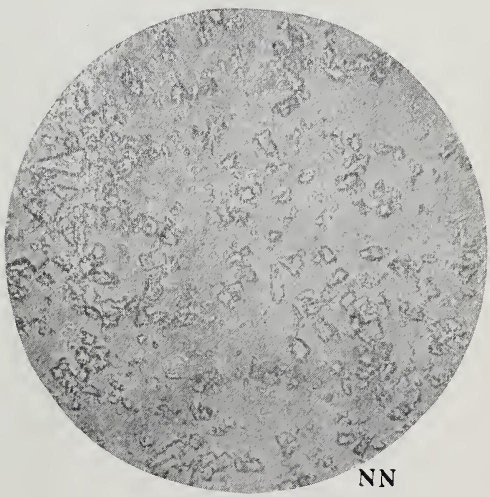
PLATE XIII.



N

German Barytes. Mag. 250 Diam.

(The Pigment shows white.)



NN

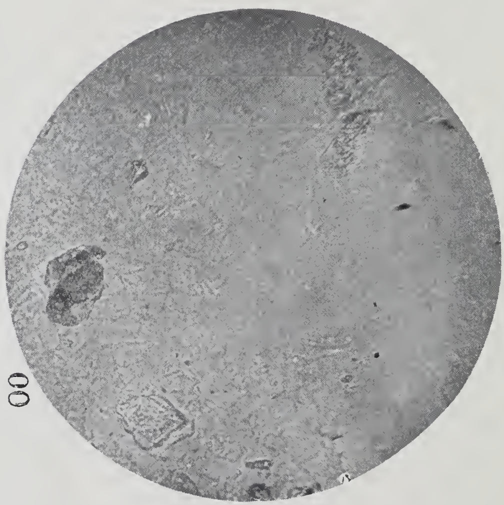
German Barytes. Same as N, by transmitted light.

(The Pigment shows black.)

PLATE XIV.

O

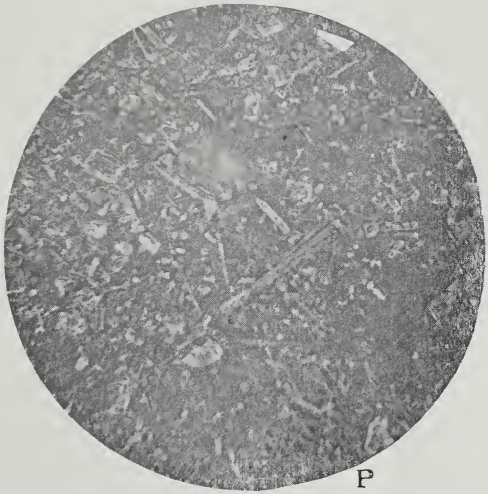
Calcium Sulphate Gypsum. Mag. 250 Diam.
(The Pigment shows white.)



OO

Calcium Sulphate. Same as O, by transmitted light.
(The Pigment shows black.)

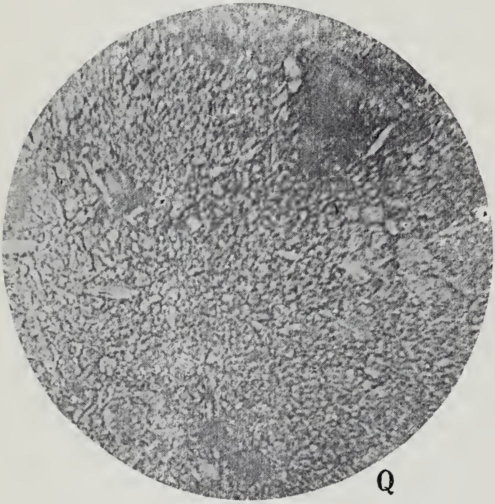
PLATE XV.



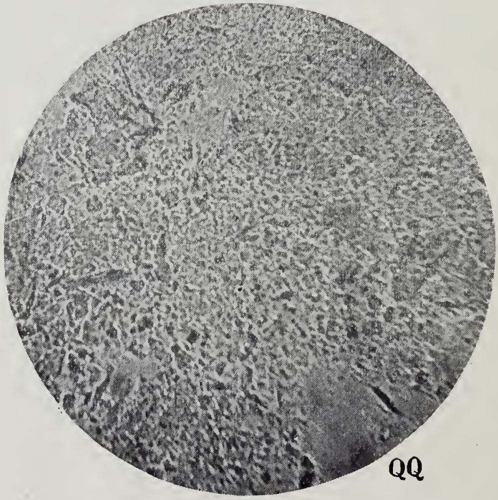
Asbestine, Magnified 250 Diameters, showing fibrous character of particles. By reflected light.

(The Pigment shows white.)

PLATE XVI.



China Clay. Mag. 250 Diam.
(The Pigment shows white.)



China Clay. Same as Q, by transmitted light.
(The Pigment shows black.)

This means that the owner by the added year saves so much on the investment per year for painters' labor that he can afford to pay yearly double the price for paint to obtain this result, but it means also that *what he saves* in buying this better paint within the extra $9 or within the total figure of $21 paint allowance instead of $12 will be a saving to him in five years in cold, hard dollars.

In like manner the dullest pencil will show that if his job gives him six, instead of four years' service he has saved $18 cash on the two extra years.

If the white lead coating chalks in three years his cost is $12 a year and then each extra year of service should he use mixed paint instead of white lead over the three years will save him the total cost of his paint, $12.

This possible economy becomes even more interesting when we consider the well-demonstrated fact that reputable machine-made paints of the scientific manufacturer give an extra durability of more than one year and usually a good, full two years over average hand-mixed lead in oil, and at less instead of greater cost for the paint on the job.

Work the sum backward and take four years as the life of the job with prepared paint, and assume chalking in the second or even the third season with lead in oil paint and the results are even more startling.

We find the factors of labor, cost and durability so important that the owner can't afford to pay over $3 for his lead in oil on a three-year life, while if his lead in oil chalks the second season, even though the Lead Trust gave him the lead free and $6 in cash, he would be out of pocket, and not only out of pocket, but three times as often he must strip his house of blinds and vines, and if he be a wise man he will send wife and children to a summer resort while the painters own the house.

PROTECTION AFFORDED BY PAINT COATINGS.

The second question involves not the cost of the painting job; but the protection to the structural material painted that can be expected from particular combinations or groupings of pigments.

Each and every pigment lacks or is below par in some one or more of the qualities of the ideal pigment

—but may possess one or more other desirable qualities in a marked degree.

No one pigment is complete in itself and the manufacturer can balance the virtues of one against the deficiencies of the other and thus obtain all the required characteristics in his blended pigment body.

Certain important pigments are not only thus deficient in requirements, but have direct injurious action upon the paint coating and the reinforcing pigments can offset or eliminate these defects.

In this connection should be instanced hydrated lead carbonate or white lead which has for hundreds of years been considered a prime and most valuable pigment. Because of its popular favor it is largely used by the manufacturers of paint, but none the less white lead has defects which beyond all other pigments the manufacturer must overcome by the addition of moderate but indispensable quantities of the "inert" or reinforcing pigments.

The defect of white lead is its alkaline nature, causing gradual and progressive attack upon the linseed oil and other materials of the paint coating. This action is cumulative: if the chemical activity of each particle be supported by close proximity of the other lead particles, then there occurs chemical action of mass, or chemical action due to juxtaposition and therefore the extension of the white lead pigment in the paint to separate its particles by the addition of a proper amount of reinforcing inert pigment is of decided assistance in mitigating the deteriorating action of white lead.

The building trades, under supervision of the architect, today use materials of great value, purchased under rigid specifications to protect the strength of the building and to prolong its life.

Structural steel has yielded up its problems to the metallurgists—the microscope, the physical testing laboratory and the chemist—and as a result the architect today is absolutely safe in building structures twenty and thirty stories high out of steel, with the knowledge that he is taking no chances on the strength and life of his building.

Cement has yielded its secrets to the same investigations and we have today reinforced concrete, which is pushing structural steel hard for first place.

Lumber has so risen in value, especially in its finer forms and better qualities that the architect strives to make each single lumber foot of it yield the greatest possible service in area and decorative effect and the necessity for the preservation of the lumber and of the values involved therein is becoming a vital problem. The preservation of heavy timber has been solved by the scientist, who today protects the railroad tie from decay and wharf piling from the toredo. The finer forms of lumber must find their protection today in paint and varnish, but the skilled architect and engineer is still prone to look upon paint entirely from the standpoint of its decorative value.

THE IMPORTANT WHITE PIGMENTS.

The more opaque and older pigments are six:

White Lead—Old Dutch.
    Quick Process; Precipitated White Lead, and Mild Process.
Zinc Oxide.
Lithophone.
Zinc Leads.
Basic Lead Sulphate (Sublimed White Lead).
Leaded Zincs.

The reinforcing pigments consist of groups of artificial and natural products.

Artificial Products.

Blanc Fixe (Barium Sulphate).
Barium Carbonate.
Lead Sulphate.
Silica (artificially produced, or precipitated silica).

Natural Products.

Paris White or Mineral Primer (Calcium Carbonate).
Silex (Natural Quartz) including infusorial earths, etc.
Barytes (Barium Sulphate).
Gypsum, (Hydrated Calcium Sulphate).
Asbestine (Talcose Hydro-Silicate of Alumina).
China Clay and Kaolin.

Old Dutch Process white lead production today involves the methods used in the middle ages, by embedding small lumps or castings of pig lead in tan bark and moistening, with addition of a little acetic acid.

The corrosion takes place more or less at hap-hazard and the nature of the process with its utter absence of scientific control explains the entire lack of uniformity in the product.

The slow method of manufacture of the Dutch Process gives rise to crystals such as are shown in plates A and B. (Pl. I.) As is well known, when a body crystalizes slowly, larger crystals are produced than when a shorter time is consumed in their precipitation, and in the case of Dutch White Lead we have ever present fairly large crystals of lead carbonate, or, as it is known mineralogically, cerusite.

The size of the Old Dutch white lead particles, vary from 1-13500 or .000074 of an inch to 1-300 or .003 of an inch. Measurement by Bausch and Lomb. (Pl. II.)

Quick process and mild process white leads, Lithophone and precipitated carbonate white lead, are extremely white pigments.

They all have their excellent characteristics of pure chemical precipitates from dilute solutions, namely, remarkable uniformity and purity and with a physical fineness or comminution only slightly less than the fume or distillation products.

These pigments are not known to have been exactly measured for size of particle, but comparative microphotographs show clearly that the particles compare about as follows:

Quick and mild process carbonate white leads somewhat coarser than the precipitated white lead. (Pl. III.)

Lithophone, the finest, somewhat larger than 1-35000 of an inch. (Pl. IV.)

The zinc oxide particles measure 1-50000 or .00002 of an inch. Measurements by Dr. W. H. Knapp, of Bausch & Lomb Optical Co. (Pl. V.)

The zinc leads and leaded zincs fall between these comminutions. Zinc leads are of varying composition but will average 50% zinc oxide and 50% lead sulphate. (Pl. VI.)

These zinc and other fire fume products are all sublimates, or air-floated fumes of metalliferous ores distilled in furnaces at high temperatures. (Pl. VII.)

The fumes are air-floated, filtered and purified from the furnace gases through the textile screens and from the very nature of their production the particles of

these materials are extremely fine and very uniform in size.

Silex, Barytes, Sulphate of Calcium, Blanc Fixe, are deficient in opacity or hiding power, but are fairly white and extremely stable or inert. They are most valuable and necessary to extend white lead and diminish or inhibit its action of chemical mass. (Pl. VIII, IX, X, XI, XIV.)

The difference is to be noted between characteristic samples of American and German Barytes. The superiority of the American goods is apparent. (Pl. XII, XIII.)

Mineral white or primer, and whiting are of greatest value in neutralizing free acids in the oil and thus diminishing the chemical action between the oil and the caustic qualities of the white lead, and they have very real values in opacity and whiteness.

Asbestine and China Clay have values in opacity and whiteness, and as inerts, but the asbestine is peculiarly valuable in its property of supporting the heavier pigments especially white lead, in proper suspension, in the liquid paint. (Pl. XV, XVI.)

The entire list of reinforcing pigments incorporate properly with linseed oil.

It is important to note that most of the artificial reinforcing pigments when ground have great uniformity in size of particles and that the natural or mineral pigments yield particles that will average in size with white lead, while the chemical or artificial products have determining size smaller than white lead but coarser than the fume or sublimated pigments.

Those reinforcing pigments which are natural products, have particles similar in size to the average of old Dutch white lead.

The chemical or artificial reinforcing pigments consist of particles which approach in size those of lithophone and precipitated white lead.

The resources for scientific paint are three groups, in point of determining size of particle and irrespective of opacity and either chemical defects or of inertness.

The coarser group, with Dutch white lead, barytes, gypsum, silex, etc.

The chemical group of medium sized precipitates with lithophone, blanc fixe, precipitated white lead, etc.

The fire group, or, sublimed group of ultimate fineness with zinc oxide, sublimed lead, etc.

NECESSITY FOR FRANK AND ACCURATE INFORMATION.

The architect finds himself puzzled when a paint manufacturer claims that the subordinate pigments add to the life of the paint coating and to its protecting values.

The manufacturer has spent large sums in advertising and in distributing commercial literature lauding his particular product. He has been urging upon the house owner, the contractor, and the architect, that his is a pure paint, its principal ingredients white lead and zinc oxide, and with a strong accent on the white lead.

But why has the manufacturer in the past glorified and sanctified the very white lead whose defects give him his greatest factory problem, in his effort to increase the protecting life of the paint? The answer to this question divides the manufacturers of machine-made paint into three groups—condemns the first group—excuses the second group and explains but does not excuse the attitude of the third group.

In the first group are those who make what the reputable and scientific manufacturers call "dope paint."

In the dope factory the subordinate pigments, because they are cheap, are used far in excess of the percentage required to offset the effects of the more opaque pigment, also far in excess of the percentage that will add new strength and life to the film of oil. They add this excess as an adulterant, cut the market price of the high-grade brands, trade on the public favor, and recognition of the value of the reliable article, and bring discredit on the industry.

But they can be easily detected—their formulas for their white colors will invariably either show heavy percentages of reinforcing pigments, usually over 30%, or will show dilution of the vehicle by the adulterating of the linseed oil. These dopers are found among the mail order houses and amongst a class who make extravagant and specious guarantees for the durability of their product. They rob the people, depending on the fact that only a small percentage of good natured Americans will seek redress through the courts.

The second class are found amongst the smaller manufacturers for local distribution. Their factories are small, they cannot support expensive chemists, testing laboratories and trained engineers, and their methods must be largely rule of thumb. This group produces some of the best paint manufactured in the country, but it also includes those who, through ignorance or intent, join the ranks of the dopers and overweight their vehicle, or impair necessary pigment quality.

The third group is made up of large national distributors of the best scientific machine-made paint their factories know how to produce. Each of these concerns shrank from the effort and expense of teaching the public that to make the best paint, groups of these same reinforcing pigments must be used—the same materials which in excess were used for adulteration or which, if used ignorantly, gave poor results.

Each concern realized that single handed, to convert the public, meant direct attack concentrated on the one concern. This lack of frankness by the paint manufacturer regarding his use of reinforcing pigments is to be deplored.

A pure food commissioner began publishing paint analyses and showed these pigments in nearly all ready-mixed products, excessively used in the dope paints, and fairly uniform percentages of this or that group in most of the scientific paints.

He unfortunately condemned their use in any form whatever, and had a law passed to this effect in his State.

Later on, upon the witness stand, it developed that he believed that the factory and modern science had not made any improvement over the old-time mixing of a hundred years ago with the hand paddle. The result of his published analyses has proven that almost unanimously the larger producers of honest goods were using the reinforcing pigments for the same purpose, and were not over-using them, and thus the commissioner has done what no one concern could do—has advertised the general use and value of these reinforcing pigments.

No bias will be found in this discussion toward any raw material whatsoever that is used in the manufacture of paint, nor in favor of any particular manufacturers' product.

The writer is president of one of the two oldest independent white lead concerns in this country, also an officer of the largest producer of Lithophone, or, Beckton White, which is a sufficient guarantee that fair treatment of the older and more opaque pigments may be expected.

PROPERTIES OF THE LIQUID PAINT.

The aim of the scientific manufacturer is to make a product which will fulfil the requirements of the liquid paint, and will approximate as closely as possible the ideal conditions of the dried coating.

The liquid paint must have the following characteristics:

1. Spreading qualities.
2. Opaqueness, or obscuring qualities.
3. Proper grinding of pigment contents.
4. Holding up qualities.
5. Brushing qualities.
6. Non-settling qualities.
7. Consistency or viscosity.

These qualities largely concern the requirement of the painter to properly apply the liquid coating, and therefore only a very brief description of these qualities will be undertaken in this connection.

SPREADING QUALITIES.

A paint must spread over a reasonably large area when brushed out, at the rate of one gallon to from 300 to 400 square feet two coat work on a fair surface. Spreading varies directly with the size or fineness of the particles of pigment in the paint. *(See diagram R.)* (Pl. XVII.)

OPAQUENESS, OR OBSCURING QUALITIES.

The pigments should be chosen with reference to their combined opaqueness and should be mixed in such proportion with the vehicle that two coats of paint will cover solid, or entirely obscure the original surface, a third coat being necessary only where an intense color already existed on the original surface.

White lead leads in this quality, volume for volume. Zinc oxide leads weight for weight, while thereafter follow in order, lithophone, sublimed lead, zinc leads and leaded zincs.

PROPER GRINDING OF PIGMENT CONTENTS

A limited proportion of the pigment must be coarse enough and of the proper physical form to give what

the skilled painter calls, proper tooth or proper feel, under the brush. White lead, silex and silicates, barytes, are valuable in furnishing this requirement. The following pigments are extremely fine: Zinc oxide, lithophone, sublimed lead.

HOLDING UP.

After the paint is stirred up the pigment should remain in suspension and not settle too rapidly in the can, so that the painter may apply uniform proportions of the vehicle and solid matter on all portions of the work.

BRUSHING OUT.

The paint should be so compounded that when applied in liquid form it will neither run nor slick, yet flow out easily without showing brush marks. In this property white lead particularly leads, either in combination or alone. In a machine-mixed paint this is obtained by so blending the pigments that the particles average smaller than 1-400″ in size.

NON-SETTLING.

The paint must be so compounded that either on the dealers' shelf, or in the warehouse, it will not settle hard in the bottom of the package within a reasonable number of years. Here again the settling qualities of each pigment being known in the laboratory, the modern factory man scientifically compounds his paints. In this property white lead is most defective, being very heavy and settling badly.

CONSISTENCY.

The liquid paint should be of a consistency which experienced painters well know and recognize—such that it will neither run off the brush too quickly, like milk, nor too thickly, like clotted cream, but more like fairly rich cream.

CHARACTERISTIC PROPERTIES OF THE IDEAL COATING.

1. Sealing quality or imperviousness of the coating.
2. Elasticity.
3. Adhesive power.
4. Opaqueness or obscuring power.
5. Freedom from internal strains.
6. Uniformity.

SEALING QUALITIES.

The ideal coating would absolutely exclude from the surface to be protected all agencies of decay—such as water, atmosphere, products of combustion, such as chimney gases with their sulphurous and carbonic acids, etc.

ELASTICITY.

The ideal coating would have such a co-efficient of expansion that it would conform to the average materials which it might be intended to cover without undue strain.

ADHESIVE POWER.

The coating should adhere with infinite closeness to the surface to be protected.

OPAQUENESS OR OBSCURING POWER.

This really falls under the heading of sealing, because it is essential that the protective coating should contain materials of sufficient opaqueness to entirely hide the surface to be protected, thus protecting it and also materially shielding the hardened vehicle of the paint itself from the actinic or chemical destructive rays of the sun.

INTERNAL STRAINS.

The ideal dried paint coating should have no areas of unequal stress.

UNIFORMITY.

The dried coating should be absolutely uniform in its composition over all areas upon which it is applied.

SCIENTIFIC PRECISION AND ACCURACY.

The writer has been greatly impressed with the advantages which would accrue to the paint manufacturer who is desirous of perfecting his product could he have at hand reliable physical data to guide him in his work.

Unfortunately, up to this time, this important field has been practically neglected, the little data obtainable resulting from more or less crude experimentation, seems to be, to say the least, faulty and unsatisfactory, so that he who today begins a scientific investigation of the physical properties of these pigments is like the sailor who embarks on an unknown sea without chart or course.

The first great obstacle that the investigator encounters in beginning this work is the difficulty (to borrow a figure from our brother, the surveyor) of obtaining an accurate base line for his triangulation, that is, to produce a set of uniform paint coatings on which to work. Hand labor and the brush needs must introduce a variable due to the personal equation of the operator, be he ever so conservative.

The result of investigations upon a great number of paint coatings where all the factors were constant, excepting this one factor of hand brushing out, has convinced the writer that until some scientifically accurate means can be developed of preparing standard paint coatings, it will be impossible to get results of precision which are comparable with each other as between even the most careful measurements on two paint coatings produced under absolutely uniform conditions excepting for this one variable.

It cannot be too strongly urged that the laboratories and technical experts connected with the corporations producing scientific machine-made paint should make an effort to eliminate this variable so that absolutely uniform paint coatings for laboratory samples can be produced from liquid paint of any given fixed composition.

In the case of the measurements and figures given as the result of the writer's investigations, the greatest care has been taken to reduce to a minimum the variable of hand brushing and the figures derived from measurements are of value for purposes of comparison, but the data given is valuable rather as pointing the way to more precise measurements than for purposes of precision.

A careful study of the viscosity and characteristics of the linoxin, with due regard to the effect upon its consistency from the admixture of the pigment particles of great fineness has convinced the writer that they incorporate with the linoxin and yield their physical qualities very largely to the vehicle or to that portion of the coating which is viscous and which determines the life of the paint coating.

The experiments which confirm the writer in this conclusion are too involved and require too much space to set forth in their detail.

They have consisted in hundreds of measurements

of the pigment particles, the paint coatings for thickness, and for tensile strength, and a discussion and exposition thereof would require an article equal to this in length.

The extremely fine particles of the sublimated or fire pigments serve the purpose that the sand serves in the reinforced concrete, and add immensely to the tensile strength.

FIRST—SEALING QUALITY OR IMPERVIOUSNESS OF THE COATING.

It has been emphasized that for durability and protection, the strength and imperviousness of a paint coating are vital factors.

The protective value of the paint coating of course ceases with its chalking or disintegration, but, while it is true that the protecting or final life of the coating ceases with this disintegration, it is also true that a paint coating has always during its true life more or less porosity from the nature of the linoxin or oxidized linseed oil.

Therefore during its protecting life the degree of its imperviousness influences its resistance to attack upon its own life and its protection of the underlying materials.

The more impervious the paint coating without loss of strength the slower the oxidation or disintegration of the paint coating itself and the greater protection to the underlying material.

A coating of linseed oil alone is not only weak, but the simplest and crudest experiments will show its porosity and this porosity increases rapidly with progressive oxidation, the porosity of course definitely hastening the over-oxidation or chalking.

In proportion, therefore, to our success in filling the voids in the linseed oil film with proper pigment materials we will in that degree succeed in excluding agencies of decay, not only from the mass of the paint coating itself, but also from the surface to be protected.

These conditions are exactly parallel in the requirements and performance of the best made concrete, and Taylor & Thompson in their work on concrete have clearly stated that to obtain imperviousness there must

be freedom from voids and that to obtain these conditions, the materials used must have at least three determining sizes.

"It is a fact that with particles of different sizes as against uniform size the densest mixture can be obtained. This is so evident as to require no proof." It follows that the least density and hence the largest percentage of voids occur when the grains are all of the same size, and it is shown that the most voids occur in a mass of large particles. The least voids occur when the voids between the large particles are filled with smaller particles and when these smaller voids between the smaller particles are in turn filled with still finer particles. In other words—particles with three determining sizes will fill up a given space more completely than particles of two determining sizes and very much more completely than particles of one size. *(See diagrams S and T.)* (Pl. XVII.)

SECOND—ELASTICITY AND STRENGTH.

The paint coating here again is governed by many of the laws which govern the similar material, *i. e.,* concrete.

We find by again refering to Taylor & Thompson, on concrete, page 275, that tests at the Watertown Arsenal on concrete convinced the investigators that the ultimate strength of a concrete is identical with the shearing strength of particles of stone making up the aggregate.

This means that in its ultimate form the good concrete will crack or shear through the broken rock contained therein, and resistance to shearing is directly proportionate to the strength of the broken rock chosen for the mixture.

The film of semi-liquid linseed oil when fresh is extremely weak, but as it hardens its characteristics and physical properties will obviously be those qualities which are a composite of the qualities of the solid particles and of the semi-solid linolein incorporated together in the paint coating.

These physical properties of the suspended and incorporated pigments profoundly modify the film in this respect.

The dried vehicle, linoxin, is notable for its elasticity and it is weak in crushing and tensile strength, and

in hardness or resistance to surface wear. The fact that it is a semi-solid furnishes an opportunity to modify and improve those characteristics of a solid in which it is deficient.

The semi-solid, rubber-like linoxin between the coarser particles of the pigment obviously uses these coarser particles as supporting points. The medium sized particles of the second group of alteration products serve the same purpose as the broken rock in concrete.

The coarser particles absolutely do not and can not serve the purpose of stiffening or of reinforcing or modifying the consistency and qualities of the semi-solid linoxin for a number of reasons, one of which may be mentioned, namely, that particles of the first or coarse class have a determining size which is a large fraction—a heavy percentage—of the total thickness of coating, and are in some instances thicker in diameter than the thickness of an oil coating not reinforced with the fine or fire group.

For example raw oil and boiled oil (each with normal percentage of thinners) spreads under a flat brush to thicknesses of .00135 of an inch and .00065 of an inch respectively, while the thickness or diameter of the large particles of Old Dutch white lead particles is .0030 inch or more than twice the thickness of the coating of the raw oil and five times the thickness of boiled oil coating.

We must think of the coarser particles as piers. The mixture of linoxin with the other two groups of particles in the spaces between these coarser particles, or piers, is the true paint body and consists of flat reinforced arches which have the extra support of false work, in the shape of the structural material on which the coating rests. Asbestine pulp, a natural product and one of our most important natural reinforcing pigments, serves not only in the coarse group as supporting particles for the linoxin arch, but also because of its peculiar properties serves the more important purposes of reinforcement. It retains, no matter how finely ground, its peculiar needle-like, or rod-like form of particles, and obviously serves the purpose of reinforcing the flat arch of linoxin, exactly as iron bars or iron netting serve in reinforced concrete arches. The medium sized particles of the second group of pigments produced by chemical alteration or precipitation,

serve the purpose of the broken rock in concrete and together with the coarser supporting particles and the finest reinforcing particles, give minimum voids and a maximum imperviousness to agencies of internal decay.

It goes without saying that the pigments of any one group contain particles of dimensions which fall into the other two groups, but no one pigment supplies the correct proportion of each of the three required dimensions and each pigment has so large a percentage of approximate dimensions as to bar it from exclusive use in the other two groups.

Given similar homogeneous coatings under identical conditions, we recognize the law that elasticity will vary, directly with thickness.

Direct deduction from this law teaches us that of two paint coatings equal in wear, in strength, opaqueness and in all other qualities except thickness, we should choose the thinner coating. Therefore if we have two paint coatings fulfilling every requirement, the first compounded with pigments giving a thicker coating and the second with pigments yielding a thinner coating, we must choose the second formula and obtain the thinner coating.

Let us turn to the thickness of well-known coatings of paint, and here we find most of the literature and data of the past faulty, in that measurements have not recognized the shrinking of the coating upon oxidation and in fact the chemist and physicist have usually based their investigations upon specific gravity and weights of coatings.

The first coat on any absorbent material must be eliminated from the calculations, and it is also true that a coating will vary in thickness depending upon the use of the round or flat brush and the personal equation or factor of application will modify the result under otherwise identical conditions.

The writer has, therefore, sought to determine the comparative thicknesses of well-known coatings under identical condition of consistency of the liquid paint, and of brushing and keeping the personal equation constant and in the hands of a master painter ignorant of the object to be sought and therefore free from conscious or sub-conscious suggestion.

Measurements made in great quantities under these conditions and with the round brush show that the

dried second coating, neglecting fractions beyond the ten thousandths of an inch, compare as follows:

A scientific machine-made paint measures, one coat	.0010″
American Green Seal Zinc, one coat	.0006″
Lithophone, one coat	.008″
Quick or mild process or precipitated lead, one coat	.0012″
Old Dutch white lead, one coat	.0015″

Neglecting fractions and taking the machine-made paint as the standard at 100 we have the others in percentages thereof:

Zinc oxide paint coating	60%
Lithophone	80%
Scientific machine-made paint	100%
Scientific white leads	120%
Old Dutch white lead	150%

In selecting the proper thickness and most elastic coating, bear in mind the necessity for pigment particles of three entirely different sizes, to produce an impenetrable paint coating; remember that the zinc oxide particles with the other sublimed pigments are extremely small, incorporate with and stiffen the linoxin and compare with the sand in concrete, that our group of alteration products are the group of medium size and compare with the broken rock in concrete and approximate average conditions, and that the Old Dutch white lead is the extreme member of the coarse group, and it is most logical that the prepared paint coating should be the correct thickness, half way between the extremely thin zinc coating and the excessively thick Old Dutch coating.

It is also noteworthy that the paint coatings of the alteration products, which have almost universally been accepted as prime necessities in the paint formulas, are found grouped around the scientific machine-made paints.

THIRD—ADHESIVE POWER.

The adhesion of the linoxin to the coarse group of particles and to the underlying material is vital to the life of the paint coating.

If the coating parts from the surface beneath we have scaling or peeling.

It is universally admitted that this will result from use of zinc oxide as the sole pigment.

We have only to conceive of our flat arch of reinforced linoxin and leave out our points of support to realize that this is the inevitable result if the coating be subject to extreme exposure, although good results may be obtained from zinc oxide used alone, as for instance, in interior house painting where extreme changes of temperature and exposure are avoided.

Three major lines of force hold our linoxin in place —adhesion toward the underneath surface, adhesion to the coarse particles and cohesion within the linoxin itself.

These lines must be represented by a flat arch of linoxin with a downward pointing magnet, therefrom to represent adhesion to the surface. Magnets on each side of the arch pointing toward the supporting coarse particles and two magnets within the arch and pointing toward each other, or to the centre of the arch, these latter to represent the force of cohesion.

FOURTH—OPAQUENESS OR OBSCURING POWER.

The actinic or chemical rays of the spectrum, that is those portions of the sun's rays which have chemical power, directly influence and excite the chemical reactions which destroy both the life of the paint coating and the life of the lumber to be protected.

Every thinking man recognizes that black absorbs and white reflects or resists these rays, when he buys light colored clothes and a straw hat in summer.

The actinic rays of light undoubtedly tend to destroy the paint film.

It is of the utmost importance that the dried paint coating shall be opaque and if this quality be obtained and a proper balance of pigments provided, reasonable durability may be expected.

OPACITY—ITS MEANING AND MEASURE.

It has been the custom of the paint trade heretofore to think of the opacity or hiding power of the pigment purely from its visual or decorative side.

The pigment which best obscured the underlying surface and in the case of lighter shades, reflected back

the greater portion of light received, to the eye, has been considered the most opaque and doubtless, therefore, other things being equal, to possess the greater protecting power. Pigments differ in their apparent opacity in accordance with their *refractive indices.* Inasmuch, however, as one of the most important functions of a pigment is to protect the underlying surface from the destructive action of the actinic rays it seemed that an investigation of the various pigments with regard to their obscuring action toward these rays were well worth while. The investigations which have been as extensive as the limited time would allow, show that we must readjust our ideas regarding the opacity of the various pigments, when dealing with the question of their behavior towards the chemical rays as compared with their action with the visual. The process worked out for a comparative determination of the photometric or actinic light, or excluding power of the various pigments, was as follows:

Various raw materials were incorporated in the same suspending vehicle and brought as near as possible to proper consistency or viscosity.

Glass slides were prepared showing one, two and three coats with sharp demarkation—these glass slides were treated as photographic negatives, *i. e.,* a sensitized silver film (standard velox paper) was exposed under each to a constant illumination and the time of exposure varied until prints of uniform density were obtained from each pigment screen—the time of development and all other conditions were constant. The development, as well as the exposure, being timed by stop watch. Considering the time of exposure for comparative purposes as a measure of their actinic light excluding value, the pigments group themselves as follows: as compared with American XX Zinc taken as 100% opacity.

Group No. 1	XX Horseshoe Zinc Oxide......	100%
	American Zinc Lead...........	100%
	Outside White Prepared Paint..	110%
Group No. 2	Sublimed Lead	67%
	G.S.Beckton White (Lithophone)	
Group No. 3	Quick Process Lead............	23%
Group No. 4	Old Dutch Lead................	17%

Group No. 5	Barium Carbonate.............	
	Paris White (Bolted).........	4%
	American Floated Barytes......	
	Blanc Fixe..................	
Group No. 6	English China Clay............	
	Asbestine Pulp...............	
	Silex.......................	2%
	Gypsum.....................	

It is interesting to note how close these photometric values compare with grouping of the pigments made with reference to fineness and also similar to the groupings made with reference to their origin. Pigments which are produced by sublimation, and which are therefore extremely fine, fall into the first group of greatest actinic exclusion or actinic opaqueness.

The materials which are chemical alteration products, or natural products produced by natural alteration or decay, fall into the second group, and are next in size of particle to the sublimated group.

Those materials which are natural products not largely modified by natural decay and which also have the largest determining size of particle, constitute the third group and have the least actinic opacity.

While these figures given—as has been said before—are now valuable only for a comparison, we may expect that in the near future by the use of accurately standardized photometers, it will be possible to express photometric values in terms of a known standard unit.

TRANSMISSION OF VISUAL RAYS.

The question naturally arises—"To what extent do the visual rays penetrating a paint coating correspond with the chemical actinic rays?" Results expressing these values are shown in the following table, being expressed in terms of American zinc as 100%, or total opacity.

TABLE OF EXCLUSION OF VISUAL RAYS.

9	American Zinc Lead......................	100%
12	XX Horsehead Zinc......................	100%
11	G. S. Beckton White......................	91.7%
13	Quick Process Lead......................	91.7%
10	Picher Lead............................	87.5%
14	Dutch Process Lead......................	87.5%

3	Barium Carbonate	75.0%
7	Paris White, Bolted	70.8%
1	Asbestine Pulp	66.6 2-3%
4	Blanc Fixe	58.3 1-3%
5	Silex	45.8 1-3%
8	Barytes, American floated	41.6%
2	English China Clay	25.0%
6	Gypsum	4.16%

In connection with these two tables showing the photometric values, it is interesting to compare the settling of the several pigments in water suspension.

The results given in the following table show the relative suspension of the several pigments in water after standing a number of months.

TABLE OF SUSPENSION OF PIGMENTS.

XX Zinc	100%
English China Clay	69%
Gypsum	46%
White Lead	39%
Barytes	15%

FIFTH—INTERNAL STRAINS.

Let the paint coating be too thick by reason of an overdose of coarse particles, and areas of unequal and great strain will occur in the arch of linoxin. These strains occur from surface drying going forward too rapidly, and from the destruction in the balance which in a scientific paint obtains between the adhesive to the coarse particles and the cohesion within the rubber-like mass of linoxin. Such over-thick coatings break down exactly as the scientists would predict from their study of these forces within the arch of linoxin. The linoxin pulverizes and the paint coating chalks.

Let the coarse particles or supports of the linoxin arch be faulty and again the laws governing the arch will tell the physicist to predict crumbling or chalking.

White lead if used alone furnishes supports for the linoxin in the shape of pigment particles that attack the linoxin chemically to form linoleate of lead or lead soap.

This destroys the arch: chalking results unless this chemical action be interfered with by admixture of other and inert pigments.

The coating must be homogeneous. It is obvious that to obtain the best results from our pigments prop-

erly mixed in accordance with physical laws, the incorporation of the pigments with the vehicle must be so complete that all portions of the resulting coating may be as near as possible of constant composition.

If there be any value or virtue in the introduction of *more* than *one* pigment into the paint coating, it follows directly that these conditions shall obtain *uniformly* throughout the coating and this must and can only mean precise formulas, arranged, of course, for any particular brand of paint according to the pigments chosen by the manufacturer from the various groups at his disposal and with due reference to these laws.

IN CONCLUSION.

The consumer or architect can only be assured of precise and carefully controlled formulas by purchasing paint made in factories where rigid control secures exact results; where highly trained experts stand over each step in the process of blending the pigments and their incorporation in the vehicle, and where the paint is made in units of great volume—thousands of gallons each day—and each batch or unit accurately tested and under the control of the chemist, the microscope and the physical testing laboratory.

CATALOGUE

Library of the Scientific Section

Petroleum and Its Products—2 Vols. —*Sir Boverton Redwood*

A Treatise on its Distribution, Occurrence, Physical and Chemical Properties, Refining and Uses

Handbook on Petroleum —*Thomson Redwood*

A Treatise on the Industrial Use of its Products.

Simple Methods for Testing Painters' Materials —*A. C. Wright*

Letters to a Painter —*Ostwald-Morse*

On the Theory and Practise of Painting

Iron Corrosion and Anti-Corrosive Paints —*L. E. Andes*

Dictionary of Chemicals and Raw Products —*G. H. Hurst*

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Oil Colors and Printers' Inks —*L. E. Andes*

A Practical Handbook Treating of Linseed Oil, Boiled Oil, Paints, Artists' Colors, Lamp Black, and Printers' Inks

Manufacture of Mineral and Lake Pigments —*J. Bersch*

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Chemistry of Paints and Painting —*A. H. Church*

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Notes on the Structure of Paint Films —*L. S. Hughes*
The Lead and Zinc Pigments —*C. D. Holley*

Transactions of the American Electrochemical Society, 1909.

Report of Tariff Committee, Paint Manufacturers' Association of the United States, 1909.

Bulletins of the Census Bureau.

Pamphlets

- The Corrosion of Iron —*A. S. Cushman*
- Corrosion of Fence Wire —*A. S. Cushman*
- Some Technical Methods of Testing Miscellaneous Supplies —*P. H. Walker*
- The Analysis of Turpentine by Fractional Distillation with Steam —*Wm. C. Geer*

Periodicals:

- Journal of Industrial and Engineering Chemistry
- Journal of the American Chemical Society
- Chemical Abstracts
- Oil, Paint and Drug Reporter
- The Decorator
- Drugs, Oils and Paints
- The Painters' Magazine
- The American Paint and Oil Dealer

Publications of the Scientific Section

BUREAU OF PROMOTION AND DEVELOPMENT

PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

Bulletin Number

Preliminary Booklet—Addresses on Paint, Delivered Before the Michigan Chapter, American Institute of Architects, 1907.

1—Tables of White Pigments and Vehicle—Standard Nomenclature.

2—Standard Can Sizes Recommended to Paint Manufacturers.

3—First Report on the Test Fences Erected by the Scientific Section. (Out of print.)

4—Methods for the Analysis of the Vehicle Constituents of Paint. (Out of print.)

5—Tests Upon the Corrosion of Iron to be Conducted by the Scientific Section. (Out of print.)

6—First Annual Report of the Scientific Section.

7—Preliminary Report on Steel Test Fences.

8—Report of Committee "E" on Preservative Coatings for Iron and Steel.

9—Recent Technical Developments in Paint Manufacture.

10—Protective Coatings for Conservation of Structural Material.

11—The Corrosion of Iron and Steel. *By Alfred Sang.* (Out of print.)

Bulletin
Number

12—The Function of Oxygen in the Corrosion of Metals. *By William H. Walker.*

13—Protective Coatings for Steel and Iron. *By Robert S. Perry.* (Out of print.)

14—Coatings for the Conservation of Structural Material. (Out of print.)

15—Protective Coatings for Structural Material. *By R. S. Perry.*

16—First Annual Report on Wearing of Paints Applied to Atlantic City Test Fence.

17—First Annual Report on Wearing of Paints Applied to Pittsburg Test Fence.

18—First Annual Report on Atlantic City Steel Test Fence.

19—Laboratory Study of Panels on Atlantic City and Pittsburg Test Fences.

20—Concrete Coatings. *By H. A. Gardner.*

21—A Brief Talk on Paints. *By Henry A. Gardner.*

22—Annual Report for 1909.

Bulletin No. 21

A Brief Talk on Paints

By HENRY A. GARDNER

Presented to the Philadelphia Branch
Master House Painters' and Decorators' Association
October 11, 1909

SCIENTIFIC SECTION
HENRY A. GARDNER, Director
BUREAU OF PROMOTION AND DEVELOPMENT
PAINT MANUFACTURERS' ASSOCIATION
3500 Grays Ferry Road
Philadelphia, Pa.

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A BRIEF TALK ON PAINTS

By HENRY A. GARDNER

Presented to the Philadelphia Branch, Master House Painters' and Decorators' Association, Oct. 11, 1909

Mr. Chairman and Members of the Association:

When I was asked to present a short talk before your branch of the Association, I felt greatly honored, as I have always heard of this branch as one of the strongest in the State, and of the State Association as the strongest body of Master Painters in the country. I have had the pleasure of working in the field with several of your members, and it therefore gives me still greater pleasure to meet you all in session and talk over subjects of mutual interest.

There is one man in the paint fraternity to-day for whom every master painter in the country has the highest respect, not only for his sterling qualities of manhood, but for his expert opinion on subjects pertaining to the painting craft. This man, John Dewar, by name, has always been a close observer, and his desire to produce the best results possible in his work has led him to keep in touch with all the latest developments and investigations which have been made during the last decade. His many years of practical experience have resulted in his formulating certain opinions regarding the relative merits of various painting materials, and in a paper presented before the Ohio State Convention of Master Painters, Mr. Dewar gave expression to several of his opinions in a masterly manner. Mr. Dewar's description of the properties and qualities of the various painting pigments so largely used to-day in the fabrication of paints should be before every master painter, and, knowing that

you gentlemen are especially interested in such work at this time, I am going to quote verbatim from his address, as follows:

"Carbonate of lead has been in use as a paint and paint base for over two thousand years, and is one of the most valuable white pigments, when considered for its covering or hiding power. It mixes perfectly with linseed oil and forms a paint which will not peel or scale. Its one great fault is its liability to chalk. This chalking is objectionable when it has proceeded to too great an extent. When white lead (basic carbonate white lead) is used in a paint, however, up to a certain extent, this chalking is reduced, and the amount that proceeds under these circumstances is just sufficient to leave a good surface upon which, in the course of time, to repaint. Basic carbonate white lead is alkaline and has the effect of damaging many delicate colors, such as Prussian blues. Another defect of basic carbonate white lead is its tendency to blacken in the presence of sulphur gases, such as we have in Pittsburg and in a number of cities in Ohio. It is apparent that reinforcing pigments should be added to white lead in order to overcome these defects. When reinforced, white lead is one of the most valuable white pigments in use to-day.

"Basic sulphate white lead is not in general use by house painters, but it is claimed for it by paint manufacturers that it is, like its sister compound, basic carbonate white lead, one of the most opaque pigments known to-day, or, in other words, it has the property of hiding the surface upon which it is applied. This pigment is very white and has great spreading properties. It is also very resistent to coal and sulphur gas and does not darken under the influence of the latter compound, as does basic carbonate white lead. Basic sulphate white lead, being a fume product, or, in other

words, being made by sublimation from lead ores, is extremely fine. Basic sulphate white lead is very stable and when used with mixtures of delicate colors, such as Prussian blues, etc., it has no action on the color, and for this reason it is largely used by paint manufacturers on account of its covering and tinting qualities.

"Zinc oxide is one of the whitest pigments which we have. It is extremely stable in its nature and may be used with delicate colors, the life of which it tends to promote. This pigment is a great spreader and will spread over more square feet of surface than most other pigments. For this reason, it should be blended with some pigment which is not such a great spreader. Zinc oxide does not chalk, and, for that reason, it serves to prevent the chalking of paint in which it is used, together with white lead. Zinc oxide carries a large proportion of oil. This explains its spreading qualities. The two defects of zinc oxide for exterior use is its tendency to peel or scale, and lack of covering quality, but by blending with coarser pigments, this tendency is overcome.

"Carbonate of lead and zinc oxide in combination. As before stated, zinc oxide, when used with carbonate of lead, to a great extent nullifies the defects of the carbonate, such as chalking and blackening in sulphur gases. In the same way, as before stated, carbonate of lead used with zinc oxide prevents the zinc oxide from scaling and renders the paint coating thicker, overcoming the great spreading power of zinc oxide. Used together, lead and zinc form one of the most valuable combinations of pigments known.

"Some of the leading paint scientists and manufacturers claim that by the addition of a small percentage of so-called inert pigments a paint may be made superior to a paint containing lead and zinc alone. I hereby note some of these

inert pigments and their characteristics when in combination, and why they are advocated.

"Calcium carbonate comes in several forms, and is termed whiting, paris white, white mineral primer, etc. This pigment neutralizes free acid in linseed oil. Although this pigment has but moderate hiding power, it has the property of increasing the density of a paint. This pigment is a non-settler. Calcium carbonate is fairly high in spreading properties and is very inert in its nature.

"Magnesium silicate. This material comes in two forms: as asbestine, which is a long, fibrous, needle-like pigment which, when used in a paint, prevents the heavy particles of the paint from settling out. It is claimed to be the ideal reinforcing pigment and it acts like hair in plaster, in holding the paint together. It also tends to resist abrasion of the paint coating. It is an extremely inert pigment and has no chemical effect upon the other pigments in the paint, and one of its most valuable properties is its ability to prevent a heavy paint from settling. The talcose variety is more tabular in structure. This pigment is very much like asbestine in its nature, as it is stable, prevents chalking, and prevents settling of a paint. The defects of asbestine and talcose are their lack of hiding and spreading properties.

"Blanc fixe and barytes. Barium sulphate comes in two forms. The natural form is barytes, and the so-called blanc fixe is the precipitated form. Both these compounds are very white and stable, but in oil they lack opacity or hiding power. They both have good brushing qualities and tooth; in fact, they greatly add to the tooth of any paint in which they are used. They have a tendency to retard chalking of a paint and are good correctives of the excessive spreading which is found in some paints. The barium sulphate is sometimes rather coarse, while the blanc fixe is ex-

tremely fine. Both these pigments are very important bases for certain colors.

"Silica or silex. This material is very stable, is an excellent filler, and has very good tooth. It is transparent in oil and should not be used to excess in a paint, but when used in moderate quantities it adds great strength and some hardness to the paint coating, overcoming the softness of certain paints."

Such complete knowledge as Mr. Dewar has outlined in the foregoing description of the properties and values of the various pigments cannot but be of great value to anyone who is studying the subject of paints. The above descriptions are thoroughly comprehensive and trustworthy, as practical tests have demonstrated. The practical tests referred to are the test fences at Atlantic City and Pittsburg, erected by the Scientific Section of the Paint Manufacturers' Association, nearly two years ago. Most of you have been in constant touch with this fence work from its conception and the erection of the fences to the last inspections, but to those who have not had an opportunity of keeping in touch with this work, a brief description will be given:

In December, 1907, the Paint Manufacturers' Association of the United States, through its Scientific Section, erected at Atlantic City, N. J., a long wooden test fence upon which were placed 560 panels of wood—white pine, yellow pine and cypress. Upon this fence was placed a series of 47 paint compositions, including a number of pure white leads. The fence was under the direction of the Scientific Section, the Master Painters' Association of Pennsylvania having control of the actual painting work. Sub-Committee "E" of the American Society for Testing Materials (on

Protective Coatings) accepted supervision and inspection of this fence and their inspector was present throughout the work.

Over a year from the date of the placement of the painted panels upon the fence, an inspection was made by representatives of the Scientific Section of the Paint Manufacturers' Association, the Master Painters' Association, and Sub-Committee "E" of the American Society for Testing Materials. In the report of Sub-Committee "E" the following statement is made:

"The Sub-Committee found that all of the pure white lead panels chalked considerably and in this respect were in less efficient condition than many of the composition paints. The relative efficiency of the latter will be reported from time to time."

A rather voluminous report was drawn up by George Butler, of Philadelphia, Chairman of the Master Painters' Fence Committee, and the following extracts are of considerable interest:

"The general conclusions which can be drawn from these tests are that a mixture of more than one prime white pigment, when used alone or in combination with a small percentage of inert pigments, makes a paint far superior to that manufactured from one pigment alone. The general failure of straight basic carbonate-white lead was so marked as to be a conclusive demonstration of the unfitness of such a compound along the coast, when used alone. A large percentage of white lead in a paint, however, even when somewhat in preponderance, so far shows excellent results when the pigments combined therewith were selected with regard to a proper balance of qualities and a proper compensation for defects.

"Gypsum apparently must be used with discretion in the paint coating, because of its solubility and liability to leach through the coating of linoxyn.

"Calcium carbonate has apparently demonstrated its efficiency in moderate percentages in the manufacture of paints, but an excess of this pigment must be avoided.

"Blanc fixe and barytes seem to be useful when the percentage used is well subordinated to the percentages of prime white pigments. The use of mixtures of these two reinforcing pigments, which are physically different, but which are chemically the same, permit advantage to be taken of the different size of particle which is exhibited by either compound.

"Magnesium silicate (asbestine) and silica, judging from the results shown by the formulas containing these pigments, would appear to have useful properties when used in moderate percentages.

"The complete failure of the formulas containing large percentages of lithopone substantiates the position of the industry in the past, of avoiding its use in considerable percentage for **outside work.**

"The formulas containing this pigment, which stood up the best, were those admixed with a percentage of zinc oxide and calcium carbonate. It is believed that a large percentage of the latter pigments, together with a more conservative percentage of lithopone will give a combination of **value for outdoor use.**

"The softness of this pigment seems to require for outdoor use the addition of such hardening agents as zinc oxide, and in the tests outlined for the future such combinations will be tried out. * * * * "It was found that of the four bases upon which para red was tried out, namely, corroded white lead, sublimed white lead, zinc oxide and lith-

opone, those which showed up the best were lithopone and white lead, the red on the latter being much brighter than on any of the others.

"In the blues, those which gave the greater permanence and the least degree of fading, were applied to panels with sublimed white lead (basic sulphate-white lead) and zinc oxide.

"The basic carbonate-white leads, which were tinted with blues, showed marked failure, and in some cases the original blue panels could not be distinguished from the panels of untinted basic carbonate-white lead because of the complete fading that had taken place. On the other hand, the sublimed white lead (or basic sulphate-white lead) and zinc oxides—which were tinted with blues—stood up remarkably well.

"It was found that the chrome green tested out is in excellent condition. It has not faded and is practically free from mildew appearance. The bronze green, however, had lightened somewhat and had whitened in some places. Mildew appearance was shown in localized spots. This appearance is possibly due to segregation of carbon."

John Dewar, in making an inspection of the fences, has stated as follows:

"The formula, 75% carbonate of lead and 25% zinc oxide, was showing up splendid, but I am free to admit that it would have been improved by the use of from 8 to 10% of inerts." * * * "I am still of the conviction that the formula as used by myself, 75% carbonate of lead and 25% zinc oxide, with from 8 to 10% of inert material, reducing the percentage of lead, would come close to making an ideal all-'round paint or base suitable to meet conditions in all localities, giving us the necessary requirements for durability, covering qualities, appearance, and the furnishing of a

suitable foundation for repainting, when diligent care is exercised in the use of the vehicle."

A similar test fence was erected in Pittsburg on the grounds of the Carnegie Technical Schools. This fence was also under the direction of the Scientific Section, and the Master Painters of Pittsburg were represented in the work, taking charge of the practical application of the formulas. The Carnegie Technical Schools' Fence Committee, composed of professors from various departments, supervised the work and were on the inspection committee that made the report after the fence had suffered a year's exposure.

The following paragraphs were taken from the report of the joint inspection committee, representing the Master Painters, the Carnegie Technical Schools and the Scientific Section:

"The results of the inspection conclusively show that a mixture of more than one prime white pigment, whether this mixture be alone or in combination with a small percentage of inert pigment, produces a paint far superior to a paint manufactured from one pigment alone.

"As a general statement of the comparative wearing of the paints, it might be said that the composite formulas are less advanced toward destruction than the paints made from single pigments, such as lithopones, white leads and zinc oxides. It is not to be understood from this statement that it is the opinion of the committee that all of the composite formulas are of equal value or that all of them are to be recommended, but it is meant that the higher types, as evidenced by the appearance of the panels, are in the above relation to the single pigment paints. * * * "The lapse of the two months between these inspections gave opportunity during which cold weather caused contraction of

the paint film which had been previously subjected to the hot summer sun, and caused marked chalking of the white lead formulas. On October 6th this chalking was just commencing, while in the December inspection it was well advanced, and at the annual inspection, had proceeded to such an extent that the pigment had been washed from the panels representing those paints which had started early chalking. * * * "The general failure of white lead, which was applied to the fence only in white, was so marked as to conclusively show the unfitness of this compound when used alone, in the Pittsburg district. However, when properly mixed with other suitable pigments, a high percentage of white lead in a paint formula showed excellent results."

Leaving aside the subject of the painting of wood, and going over to the vital problem of the proper protection for steel and iron, it will not be out of place to bring before you as master painters the much discussed subject of galvanized iron painting.

You doubtless all have your pet formulas, and each one may be more or less satisfactory. Many preliminary treatments of the galvanized surfaces have been recommended, such as the treatment with vinegar, lemon juice, alkali, copper salts, and sal ammoniac. Each of these solutions, when applied to the galvanized surface, will cause a disappearance of the greasy smoothness, and leave a peculiar roughness that allows greater adhesion of the paint. It has been demonstrated, however, to the satisfaction of many master painters that good results can be accomplished without the above preliminary treatments, by the use of inert pigments ground in varnish. Specially prepared silica is of great value for this purpose

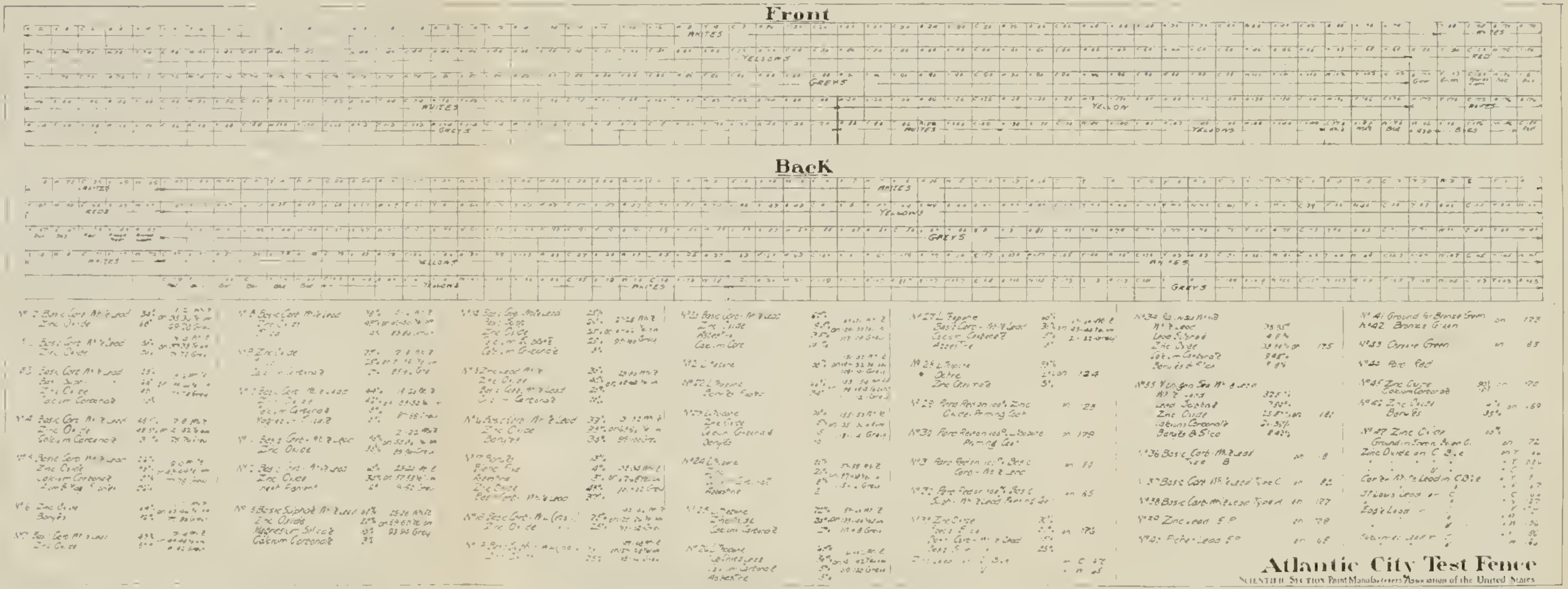
You are all more or less familiar with the new theory

of rust inhibition that has been occupying the attention of many prominent master painters of late, and it is believed that the use of the so-called inhibitive pigments will, in the very near future, solve the question of rust prevention. The so-called inhibitive pigments are pigments which are not chemically or electrically active when in the presence of iron, and which prevent the flow of electric currents through the iron. Pigments of the carbonaceous group, which are good conductors of electricity, have proven themselves stimulators of corrosion, and are considered dangerous materials to apply to iron and steel. Pigments of the inhibitive group are non-conductors of electricity and render the steel surface, upon which they are applied, passive to electrolysis, and prevent rust from forming. Examples of such pigments are zinc oxide and zinc chromate. When used in certain proportions in a paint coating they have proven themselves of the greatest value in preventing rust. The steel test fences at Atlantic City, which the Scientific Section has erected, are giving a practical demonstration of the value of all the best known pigments when ground in oil and painted out on steel. It is urged that upon your next visit to the seashore you will all make a careful inspection of these plates and draw your own conclusions as to the best pigments to use for this work. The attached chart will prove of value to you in making this inspection. You will also find attached a cut of the Atlantic City Wooden Test Fence, showing the formulas applied and position of the panels. The chart on the following page gives the condensed report of inspection:

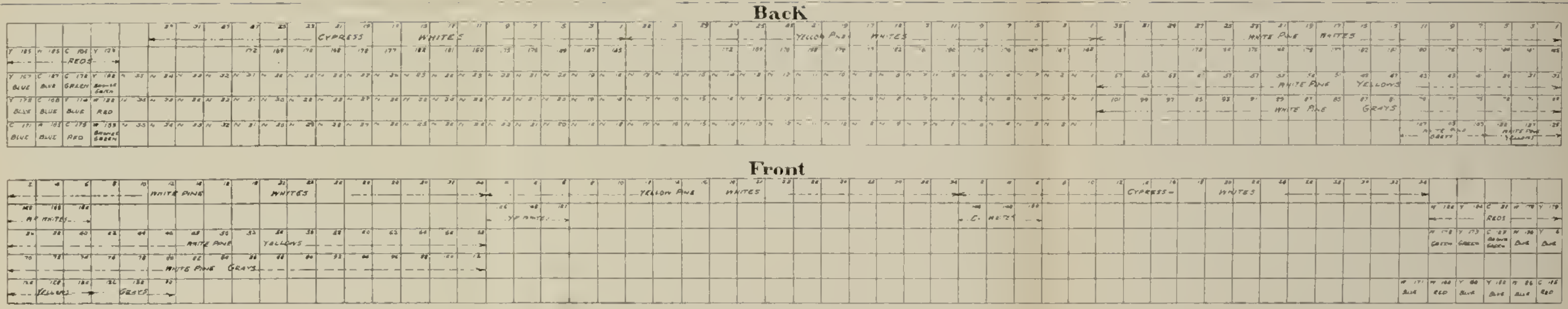
CONDENSED REPORT OF INSPECTION OF ATLANTIC CITY FENCE, MARCH 26 AND 27, 1909

Formula No.	Panel No.	Condition	Hiding Power	Color (whiteness)	Hardness	Checking	Chalking	Gloss	Remarks
1	1	Good	Good	Excellent	8		Very slight	High—even	Like rubbed varnish work
2	3	Good	Good	Good, bluish tone	5	Hard matt	Moderate	Medium high	
3	5	Good	Fair	Good, ivory tone	4		Medium	Slight	
4	7	Good	Good	Good	5		Very slight	Medium high—uniform	
5	9	Good	Weak	Good	8½		Slight	High	Hard Surface
6	11	Fairly good	Weak	Good	8	Matt checking		Good	Surface rough
7	13	Good	Good	Off color slightly, ivory tone	7		Slight	High	
8	15	Good	Good	Good	8½		Slight	High	
9	17	Fair	Poor	Good	9	Heavy matt		High	Peeling started
10	19	Good	Fair	Good	5		Some	Medium high	
11	21	Good	Good	Excellent	7½	Medium	Some	Medium high	Some washing and discoloration of the coa
12	23	Good	Medium	Good	4	Heavy matt	Bad	Medium	
13	25	Good	Good	Good	4		Medium	Fair	
14	27	Bad	Medium	Good	5	Evident	Some	Medium	Dead, spongy surface. White incrustation inently shown
15	29	Good	Medium	Good	8½	Coarse matt	Slight	High	
16	31	Fair	Fair	Good	7½	Bad	Slight	Good	White incrustation
17	33	Good	Fair	Good	4		Some	Fair	
18	145	Good	Good	Excellent	3	Hard matt	Moderate	Medium	
19	147	Good	Good	Excellent	2	Hard matt	Slight	Very little	
20	149	Good	Good	Good	5		Very little	Medium	
33	176		Fair					Good	Rough surface
40	168	Good	Good	Good	2	Some	Considerable	Egg shell	
46	169	Fair	Good	Good	9	Some		Good	
45	170	Fair	Fair	Good	9	Very evident		High	Not uniform conditions for comparative insp with rest of panels because W P is missi oversight on this exposure
47	172		Good	Good	10	Apparent		Good	Indications of scaling
34	175	Good	Medium	Good	4	Evident	Slight	Egg shell	Same conditions as apparent on C panel, and split and checked
38	177	Bad	Good	Good	1	Bad	Bad	Egg shell	Cracking and perishing evident
39	178	Good	Fair	Good	6		Some	Good	
35	180	Good	Good	Good	4	Matt		Egg shell	
36	181	Bad	Good	Good	1	Very apparent	Bad	Egg shell	About same as panel 177, but checking not so apparent
37	182	Bad	Good	Good	1	Very apparent	Bad	Egg shell	About same as panel 177

PANEL CHART OF ATLANTIC CITY TEST FENCE



On this chart is given the formula number and percentage composition of each paint. The numbers following the formulas represent the panels upon which the paints were applied, in white, yellow and gray



PRESENT ARRANGEMENT OF PANELS ON ATLANTIC CITY FENCE

Showing the new Formulas applied to back. These are designated as "N" and are in White Yellow & Gray upon White Pine wood

CATALOGUE

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Simple Methods for Testing Painters' Materials —*A. C. Wright*

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Iron Corrosion and Anti-Corrosive Paints —*L. E. Andes*

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Manual of Quantitative Chemical Analysis —*E. F. Ladd*
Techno-Chemical Analysis —*Lunge-Cohn*
Tests and Reagents, Chemical and Microscopical —*A. L. Cohn*
Spectrum Analysis —*Laudauer-Tingle*
Microscopy of Technical Products —*Hanausek-Winton*
Manipulation of the Microscope —*Edward Bausch*
Micro-Chemical Analysis —*Behren*

Clays, Their Occurrence, Properties and Uses —*Heinrich Ries*
The Electric Furnace —*Alfred Stansfield*
Oil Analysis —*Augustus H. Gill*
The Colorist —*J. A. H. Hatt*
Paint and Color Mixing —*A. S. Jennings*
An Outline of the Theory of Solution and Its Results —*J. L. R. Morgan*
Notes on the Structure of Paint Films —*L. S. Hughes*
Pamphlets
- The Corrosion of Iron —*A. S. Cushman*
- Corrosion of Fence Wire —*A. S. Cushman*
- Some Technical Methods of Testing Miscellaneous Supplies —*P. H. Walker*
- The Analysis of Turpentine by Fractional Distillation with Steam —*Wm. C. Geer*

Publications of the Scientific Section

BUREAU OF PROMOTION AND DEVELOPMENT

PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

Bulletin Number

Preliminary Booklet—Addresses on Paint, Delivered Before the Michigan Chapter, American Institute of Architects, 1907.

1—Tables of White Pigments and Vehicle—Standard Nomenclature.

2—Standard Can Sizes Recommended to Paint Manufacturers.

3—First Report on the Test Fences Erected by the Scientific Section. (Out of print.)

4—Methods for the Analysis of the Vehicle Constituents of Paint. (Out of print.)

5—Tests Upon the Corrosion of Iron to be Conducted by the Scientific Section. (Out of print.)

6—First Annual Report of the Scientific Section.

7—Preliminary Report on Steel Test Fences.

8—Report of Committee "E" on Preservative Coatings for Iron and Steel.

9—Recent Technical Developments in Paint Manufacture.

10—Protective Coatings for Conservation of Structural Material.

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Bulletin
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12—The Function of Oxygen in the Corrosion of Metals. *By William H. Walker.*

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16—First Annual Report on Wearing of Paints Applied to Atlantic City Test Fence.

17—First Annual Report on Wearing of Paints Applied to Pittsburg Test Fence.

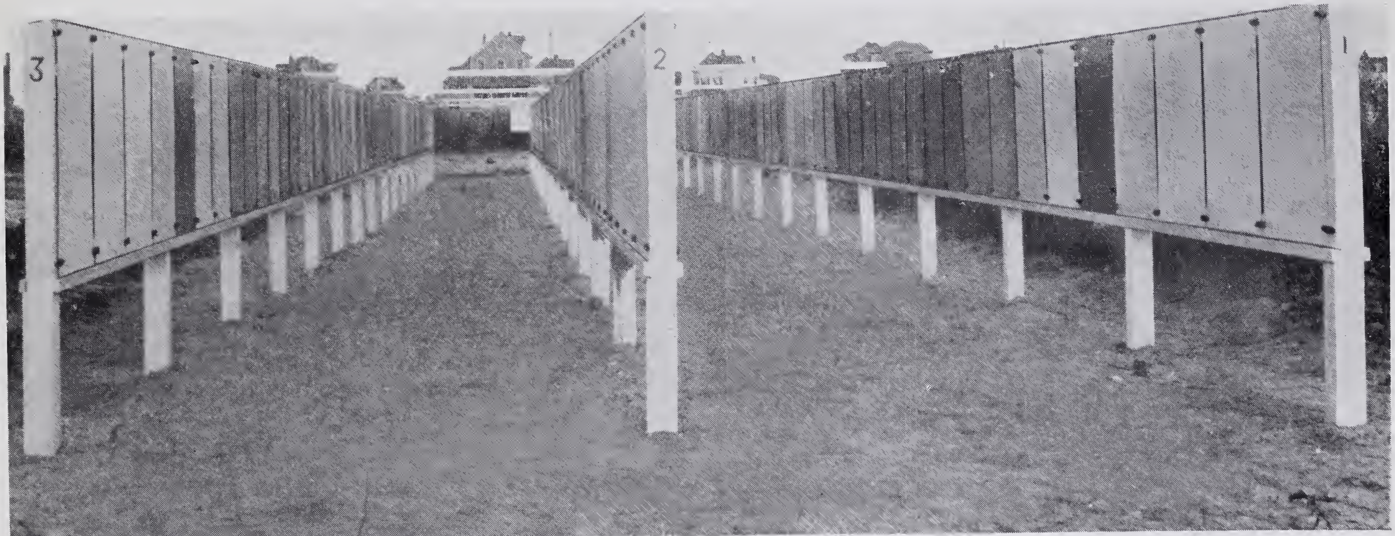
18—First Annual Report on Atlantic City Steel Test Fence.

19—Laboratory Study of Panels on Atlantic City and Pittsburg Test Fences.

20—Concrete Coatings. *By H. A. Gardner.*

21—A Brief Talk on Paints. *By Henry A. Gardner.*

VIEW OF ATLANTIC CITY WOODEN TEST FENCE



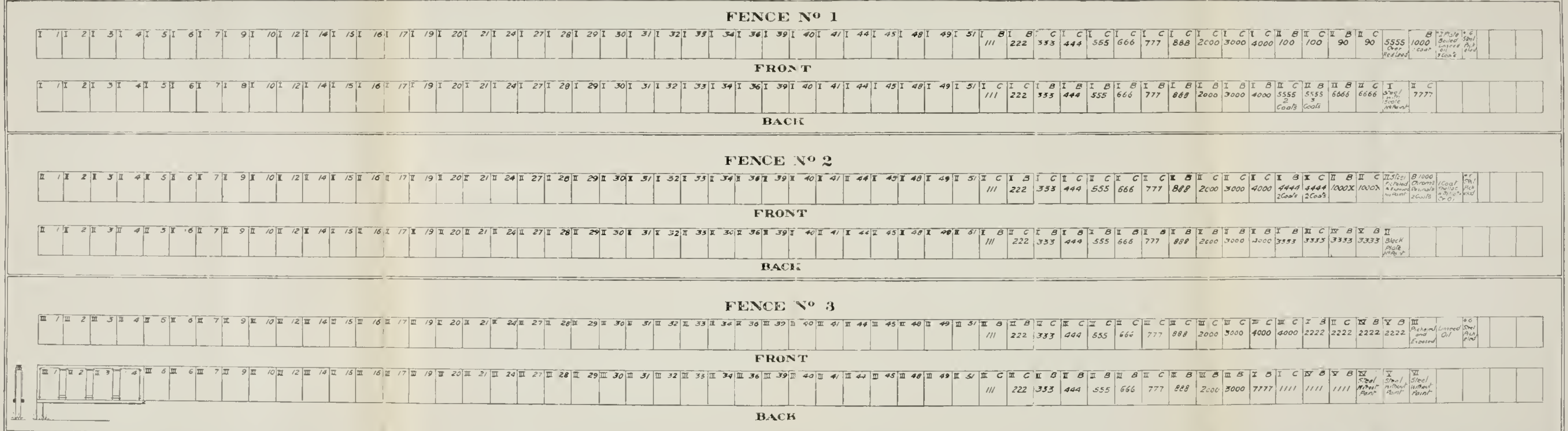
SIDE VIEW OF THE STEEL TEST FENCES

ERECTED, PAINTED AND EXPOSED,
OCT 16, NOV 16, 1908.
LOCATION—DOVER AND VENTNOR AVES.

DIAGRAM

PAINT TEST—STEEL FENCE
ATLANTIC CITY, N. J

H. A. GARDNER
DIRECTOR OF TEST
SCIENTIFIC SECTION
PAINT MANUFACTURERS ASSOCIATION



No 1 Dutch Process White Lead
No 2 Quick Process White Lead
No 3 Zinc Oxide
No 4 Sublimed White Lead
No 5 Sublimed Blue Lead
No 6 Lithopone
No 7 Zinc Lead White

No 9 Orange Mineral American
No 10 Red Lead
No 12 Bright Red Oxide (62 d)
No 14 Venetian Red
No 15 Princes Metallic Brown
No 16 Natural Graphite
No 17 Acheson Graphite

No 19 Lamp Black
No 20 Willow Charcoal
No 21 Gas Carbon Black
No 24 French Yellow Ochre
No 27 Barytes Natural
No 28 Barytes Precipitated
No 29 Calc. Carb. (Whiting)

No 30 Calc. Carb. Precipitated
No 31 Calcium Sulphate (Gypsum)
No 32 China Clay (Kaolin)
No 33 Asbestine (Silicate Magnesium)
No 34 American Vermilion (Chrome Scarlet)
No 36 Med. Chrome Yellow
No 39 Zinc Chromate

No 40 Zinc & Barium Chromate
No 41 Chrome Green (Blue Tone)
No 44 Prussian Blue (Stimulative)
No 45 Inhibitive Prussian Blue
No 48 Ultramarine Blue
No 49 Zinc & Lead Chromate
No 51 Magnetic Black Oxide

No 30 Straight Lamp Black Paint with Turps & Dryer
No 100 " " Carbon " " " " "
No 1000 Chrome Resinate in oil
No 2000 1 Coat Zinc Chromate 1 Coat Excluder
No 3000 1 " Lead " " 1 " "
No 4000 1 " Red Lead 1 " "
No 111 Brown Inhibitive Paints

No 222 Black Inhibitive Paints
No 333 White " "
No 444 Green "
No 555 Black Stimulative Paints
No 666 Brown " "
No 777 White " "
No 888 Green " "

No 1111 Green Special G Formula
No 2222 Red " "
No 3333 Black " " "
No 4444 A. Excluder Paint
No 5555 Coal Tar Paint
No 6666 Special Paint
No 7777 Special Gl Paint

Analysis of Steel in Plates

	No 1 Fence	No 2 Fence	No 3 Fence	No 4 Fence	No 5 Fence	No 6 Fence
	Bessemer Steel	Open Hearth	Pure Iron	Special Bessemer	Special Charcoal	Spellerized
Carbon	.08	.16	.03	Steel	Iron	Steel
Manganese	.35	.44	Bare Trace			
Phosphorous	.08	.02	.005			
Sulphur	.05	.024	.024			

Roman Numerals = Class of Steel
Arabic Numerals = Number of Paint

"B" = Black Plates with scale
"C" = Pickeled Plates

Plates pickeled in Sulphuric Acid were used throughout on the pigments up to "51, using a definate spreading rate of 300 Sq. ft per gallon, in applying the paint. Above this number, cleaned plates were used with the definate spreading rate as above, and black plates were used without any spreading rate.

Bulletin No. 22

Annual Report for 1909

Scientific Section

HENRY A. GARDNER, Director

Bureau of Promotion and Development

PAINT MANUFACTURERS' ASSOCIATION

3500 Grays Ferry Road

Philadelphia, Pa.

Annual Report for 1909

SCIENTIFIC SECTION

HENRY A. GARDNER, Director

BUREAU OF PROMOTION AND DEVELOPMENT
PAINT MANUFACTURERS' ASSOCIATION
OF UNITED STATES
3500 Grays Ferry Road, Philadelphia, Pa.

Annual Report for 1909

MR. NORRIS B. GREGG, Chairman,
Bureau of Promotion and Development,
Paint Manufacturers' Association of the
United States.

Sir:—

I have the honor to present to you a summary of the work accomplished by the Scientific Section of the Bureau of Promotion and Development during the past year, together with a summary of future work, which will occupy the Section for the next twelve months.

Appointment as Director

All the work of the Scientific Section from its organization until July, 1909, was under the directorship of Mr. R. S. Perry. Mr. Perry's resignation from the Bureau was made on May 19th, at a meeting held in Atlantic City, N. J., and finally accepted by the Bureau at its Cleveland meeting, held on the 19th of July, at which time I was selected to fill the vacancy.

Work on Steel Test Fences

Directly after the last Association meeting, which was held in New York at the Hotel Belmont, October 18, 1908, work was started in Atlantic City, N. J., on the erection and painting of three steel test fences, this work having been approved by the Bureau. The panels on these fences were painted with the

various pigments and paints which had been under examination by the Scientific Section working in conjunction with various committees representing the American Society for Testing Materials. Full details of this work, together with an outline of the theory of rust inhibition, were presented to the members of the Association in the Preliminary Report on Steel Test Fences, issued last December. Inspections of the steel test fences have been made from time to time, and the results to date are given in the First Annual Report on the Atlantic City Steel Test Fence, which was presented to the members of the Association as Bulletin No. 18, during August of this year.

Addresses Made During Winter

During the winter months the Scientific Section kept in very close touch with various schools and colleges, technical organizations, architectural societies, and master painters' associations. Several addresses were made before these bodies, on the subject of paints for various purposes, and these addresses were printed in bulletin form and sent to the Association. This educational work was started early in January and continued up through May, Bulletins Nos. 9 to 15 having been prepared for this work.

Laboratory Work Resumed—Research and Analytical

Later in the winter, the Scientific Section resumed the laboratory work which had been practically discontinued for nearly six months. The services of two chemists were secured, one for research and technical work, and one for analytical work. A series of very important

investigations were at once started, some of which have been finished, others being still under way.

The results obtained from these investigations will form the basis of further bulletins which are to be issued by this Section.

Preparing for Fence Inspections

During the months of March and April, the Scientific Section was kept very busy preparing for and making the First Annual Inspections of the Atlantic City and Pittsburg wooden test fences. Considerable preliminary work was necessary in order to properly co-operate with the various associations interested in these fences, and prepare for the inspections. These fences are the most important field tests ever undertaken in this country, and they represent the combined interest of the paint technologist—the manufacturer and the master painter.

Report of Inspections

After the inspections had been made, work was started on Bulletins Nos. 16 and 17. The production of these books required the constant work of the Director and his assistants for nearly three months, because of their voluminous nature, each being over three hundred pages in size. It was recognized that the two wooden fences, at Atlantic City and Pittsburg, were the most important work ever undertaken by this Section and that the results obtained would be of great practical use and benefit to the members of the Association, both from a technical and financial standpoint.

Value of Reports to Mixed Paint Manufacturers

The proof obtained through these fences, that a combination of more than one pigment is of greater value than the use of single pigments alone, justifies the expenditures incurred in the erection and maintenance of the fences. That the paint trade at large thoroughly appreciates the value of such tests is evidenced by the great demand for the Educational and Commercial Section's Paint Modernism Tabloids which contain excerpts from both the Atlantic City and Pittsburg Test Fence reports, as follows:

> "The general conclusion, thus far is that two or more of the prime white pigments, when ground together, or with moderate percentages of the inert reinforcing pigments, make a paint far superior to that manufactured from one pigment alone."
>
> **"At Atlantic City is was found:—** 'That all of the Pure White Lead panels chalked considerably, and in this respect were in less efficient condition than many of the Combination Paints.' "
>
> **"At Pittsburg it was found:—** 'That the general failure of White Lead, which was applied to the fence only in white, was so marked as to conclusively show the unfitness of this compound when used alone, in the Pittsburg District. However, when

properly mixed with other suitable pigments, a high percentage of White Lead in a paint formula showed excellent results.' "

Co-operation with Professional and Industrial Section

During the past year the Scientific Section has been working in harmony with the Educational and Commercial Section, and if the Association desires the architects and other important men who specify paints to be kept in constant touch with the latest developments on this subject, it will be necessary for the Scientific Section to continue to furnish the Educational and Commercial Section with working material of such an important nature. An endeavor will be made during the coming year to keep in closer touch with the Professional and Industrial Section, and render any possible aid to them in their work.

Office Organization of Scientific Section

The Scientific Section has found it necessary to employ a stenographer for the large amount of routine work contingent with the maintenance of the office, and for the proper care of the literature—publications and library of the Section. This Section carries a very heavy daily correspondence with the members of the Association, with government and State officials, colleges, universities, master painters' associations, engineers' societies, and others interested in our work. Proper care of such correspondence necessarily requires constant touch with the scientific and technical world, and in order to properly administer and supervise the laboratory and field work.

Recent Bulletin on Laboratory Inspection of Panels

Bulletin No. 19, which has just been issued, contains the results of the laboratory inspection of the panels upon the Atlantic City and Pittsburg Test Fences, and gives an immense amount of interesting and valuable data which goes to confirm the original results obtained. The results of these investigations, as published in this bulletin, may in the opinion of some be more important and conclusive than those in Bulletins Nos. 16 and 17, because of the scientific precision and accuracy obtainable from laboratory inspection methods.

Bulletin on Concrete Coatings

During the summer months, the laboratory made a very careful study of the subject of painting concrete, supplemented by a series of analyses and investigations into the value of the various marketed compounds designed for that purpose. The results of these investigations, and the conclusions therefrom, are embodied in Bulletin No. 20, which will give to the members of the Association a very clear idea of the physical and chemical problems which must be considered in designing a paint coating to be used upon cement or concrete surfaces.

Iron Oxide Investigations

At the present time the laboratory is working upon a series of analyses of the various iron oxides of the United States. Large samples from all over the country are being secured and very carefully analyzed. The products are also tested for their tinctorial strength and tone, and the samples are afterward carefully filed away, labelled with the in-

formation which has been obtained regarding their source, value for painting iron or wood, and other properties.

Analysis of Oils

Another series of very important investigations are being made in the research department, upon paint coatings of various natures, and upon the effect of driers, oils, japans, etc., upon paint coatings. A series of oils are being tested for their purity, and the results of these tests will furnish material for a bulletin later in the winter.

Colleges Desire Information Regarding Paints

Several requests have been received from master painters' associations, colleges, and technical bodies for addresses to be made by the Scientific Section, on the subject of paints, and, as far as possible, these requests will be complied with and the addresses will be issued in the form of bulletins, as heretofore.

New Wooden Test Fences for the South and West

The Scientific Section has had a strong desire to erect fences in the South and West, in order to determine the value of the single pigments as contrasted with the various combinations in the two climates. The methods for carrying out such an important work have been carefully considered, and many improvements in the design and outline of such tests have been made. Heretofore the test fences have given the relative value of various pigments and mixtures of pigments, the vehicle in each case being constant. In future the tests will be of vehicles as well as pigments, and the possible effect of driers will also be determined. The Section has had a correspondence with

universities in the South and West, where work of this sort would be welcomed. The fences would probably be placed under their supervision, working in co-operation with various technical societies and master painters' associations, so as to make the tests as authoritative as possible.

Necessity of Continued Support

Although the Bureau has approved of the test fences which the Section desires to erect, it has been impossible to do any work upon this subject because of the lack of funds, and it is sincerely hoped that the members of this Association will recognize the great value of such tests, and promptly contribute their share and proportion for the execution of such work.

Use of Library and Co-operation with Factory Chemical Force

It is urged that the members of the Association make further use of the library, and try to keep in more constant touch with the work of the Section, either by correspondence or by visits to the laboratories, where the Section chemists will gladly go into the detail of the work under way.

H. A. GARDNER,
Director.

CATALOGUE

Library of the Scientific Section

Petroleum and Its Products—2 Vols. —*Sir Boverton Redwood*

A Treatise on its Distribution, Occurrence, Physical and Chemical Properties, Refining and Uses

Handbook on Petroleum —*Thomson Redwood*

A Treatise on the Industrial Use of its Products.

Simple Methods for Testing Painters' Materials —*A. C. Wright*

Letters to a Painter —*Ostwald-Morse*

On the Theory and Practise of Painting

Iron Corrosion and Anti-Corrosive Paints —*L. E. Andes*

Dictionary of Chemicals and Raw Products —*G. H. Hurst*

Used in the Manufacture of Paints, Colors, Varnishes and Allied Preparations

Oil Colors and Printers' Inks —*L. E. Andes*

A Practical Handbook Treating of Linseed Oil, Boiled Oil, Paints, Artists' Colors, Lamp Black, and Printers' Inks

Manufacture of Mineral and Lake Pigments —*J. Bersch*

Containing Directions for the Manufacture of All Artificial Artists' and Painters' Colors, Enamel Colors, Soot and Metallic Pigments

Chemistry of Paints and Painting —*A. H. Church*

Painters' Laboratory Guide —*G. H. Hurst*

A Handbook on Paints, Colors and Varnishes

Pigments, Paints and Painting —*A. T. Terry*

A Practical Book for Practical Men

Rustless Coatings, Corrosion and Electrolysis of Iron and Steel —*M. P. Wood*

Mixed Paints, Color Pigments and Varnishes —*Holley and Ladd*

Chemical Technology and Analysis of Oils, Fats and Waxes, Vols. 1 and 2 —*J. Lewkowitsch*

Chemistry and Technology of Mixed Paints —*M. Toch*

Chemistry of Paint and Paint Vehicles —*Hall*

Testing and Valuation of Raw Materials Used in Paint and Color Manufacture —*M. W. Jones*

Painters' Colors, Oils and Varnishes —*G. H. Hurst*

The Manufacture of Varnishes and Kindred Industries—2 Vols. —*Livache and McIntosh*

The Manufacture of Lake Pigments from Artificial Colors —*F. H. Jennison*

Drying Oils, Boiled Oil and Solid and Liquid Driers —*L. E. Andes*

A Practical Work for Manufacturers of Paints, Oils, Varnishes, etc.

Students' Handbook of Paints, Colors, Oils and Varnishes—*John Furnell*

House Painting . —*A. H. Sabin*

The Microscope —*S. H. Gage*

A Treatise on Color Manufacture —*Zerr & Rubencamp*

Outlines of Qualitative Chemical Analysis —*Gooch & Browning*

Manufacture of Paint —*J. Cruikshank Smith*

A Practical Handbook for Paint Manufacturers

The Chemistry of Pigments —*Parry & Coste*

House Decorating and Painting —*W. Norman Brown*

A History of Decorative Art —*W. Norman Brown*

Notes on Lead Ores —*Jos. Fairie*

Their Distribution and Properties

Technology of Paint and Varnish —*A. H. Sabin*

Oil Chemists' Handbook —*Hopkins*

Proceedings of the American Society for Testing Materials—11th Annual Meeting.

Chemiker-Kalendar—1908.

Principles of Reinforced Concrete Construction —*Turneaure & Maurer*

Mechanical Engineer's Handbook —*Wm. Kent*

Outlines of Inorganic Chemistry —*Gooch & Walker*

Table of Minerals —*Samuel Lewis Penfield*

Including the Uses of Minerals and Statistics of the Domestic Production

Food Inspection and Analysis —*A. E. Leach*

Enzymes and Their Applications —*Effront-Prescott*

Determinative Mineralogy and Blowpipe Analysis —*Brush-Penfield*

Physics —*Ganot*

Analytical Chemistry—Volumes 1 and 2 —*Treadwell-Hall*

Quantitative Chemical Analysis by Electrolysis —*Classen-Boltwood*

Text-book of Chemical Arithmetic —*H. L. Wells*

Elements of Physical Chemistry —*J. L. R. Morgan*

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20—Concrete Coatings. *By H. A. Gardner.*

21—A Brief Talk on Paints. *By Henry A. Gardner.*

22—Annual Report for 1909.

Bulletin No. 23

The Theory of Driers and Their Application

SCIENTIFIC SECTION—EDUCATIONAL BUREAU

HENRY A. GARDNER, Director

PAINT MANUFACTURERS' ASSOCIATION
OF THE UNITED STATES

3500 Grays Ferry Road

Philadelphia, Pa.

The Theory of Driers and Their Application

SCIENTIFIC SECTION—EDUCATIONAL BUREAU
HENRY A. GARDNER, Director
PAINT MANUFACTURERS' ASSOCIATION
OF THE UNITED STATES
3500 Grays Ferry Road, Philadelphia

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THE THEORY OF DRIERS AND THEIR APPLICATION

The General Problem of Driers and Their Application: The problem of the drying of oils and their behavior with various siccatives in varying quantity is a very interesting one, and, obviously, of considerable importance from a practical standpoint. Unfortunately there is a decided paucity of reliable literature dealing with the subject for the guidance and edification of those concerned in the manufacture or application of siccative products. Furthermore, when the problem is investigated, it is not difficult to readily see the reason why this is the case.

At a glance, it is evident that a decided obstacle in experimentation on the drying properties of oils is the difficulty in obtaining identical conditions for comparative purposes. Inasmuch as a multitude of factors, such as uniformity and homogeneity of the siccatives and the oils themselves, intensity and source of light, temperature, uniformity of application, and many others, play a decisive part in the siccative tendencies of oils, the resources and ingenuity of the chemist engaged in the research are severely taxed.

It is likewise hazardous to make dogmatic statements on the subject, owing to exactly those circumstances just mentioned and thus the object of this paper is rather to contribute from knowledge ob-

tained through our experiments, to the data already available through the work of other investigators in this field, than to lay down rules to be followed.

Metamorphosis of Oil Caused by Oxygen: It is a well-known fact that linseed oil, being an unsaturated compound, when applied to a clean surface, such as a glass plate, will undergo oxidation and take up oxygen to the extent of about 16%, forming a hard, elastic, non-sticky product which has been called linoxyn. This material, unlike the oil from which it has been formed, is insoluble in most solvents. Other oils, such as cottonseed, hemp, rape, olive, etc., are more fully satisfied in nature and have not the power to absorb the amount of oxygen taken up by linseed oil. For this reason they never dry to that same hard condition presented by linseed oil. Petroleum oils have no power of drying, and their use, therefore is never allowed in a good paint. This, of course, does not apply to petroleum spirits which are used as thinners for paints. The latter products, being volatile, evaporate when spread out and do not interfere with the drying of paint in which they are used.

Drying Tests Carried out by Scientific Section: With paints it is impossible to secure films as thin as those presented by layers of oil on glass, nor would it be desirable to secure films of this same relative thickness. For this reason, the tests carried out by the Scientific Section, on the drying properties of linseed oil containing various percentages of driers, were made upon films of the same relative thickness as that possessed by the average coating of paint. The results obtained will thus be more useful and indicative

of results to the paint manufacturer to use in actual service. The drying of the films did not take place in the short period, nor in the same ratio, as with the thin layer that is secured by flowing oil upon glass. The results, however, are more practical, and of more value to the manufacturers as they have been carried out.

Methods Used in Conducting Tests: In carrying out the tests, a quantity of pure linseed oil of the following analysis was secured:

Specific Gravity at 15 deg. C.	.934
Acid Number	5
Saponification Number	191½
Iodine Number	188

This oil was distributed into nearly three hundred 8 oz. oil sample bottles, and to a series of these bottles was added varying quantities of a very concentrated drier made by boiling oil to 400 deg. in an open kettle, with the subsequent addition of lead oxide. The amount of drier added to each bottle varied according to the percentage desired, being calculated on the lead content of the drier, which was very accurately determined by analysis.

There was secured in this manner a series of oils containing varying amounts of lead oxide, and from this lot were selected a certain number of samples which would be representative and typical of paint vehicles now found in the market.

Another series of tests were made by combining with a large number of samples of pure linseed oil as used above, various percentages of a manganese drier made by boiling oil at 400 deg. and incorporating therewith manganese dioxide.

Still another series of tests were made upon a number of oils into which were incorporated various small quantities of lead oxide and manganese oxide together, using the standard driers made in the above manner, all of which were carefully analyzed to determine their contents.

In view of the errors in manipulation that could occur where so many tests were made, it was not deemed advisable, in carrying out the tests, to use glass plates, on which only a minute quantity of oil could be maintained. A much better solution of the difficulty presented itself in using a series of small, round, crimped edge tin plates about three inches in diameter, such as are used for lids of friction top cans. These were carefully numbered in consecutive order, corresponding to the numbers on the various samples of oil. A very small quantity of oil was then placed in each of the can covers, which were previously weighed, and allowed to distribute itself over the bottom surface thereof. Reweighing of the covers gave the amount of oil which was taken for each test. The test samples on the covers were all placed in a large box with glass sides, having a series of perforated shelves. In the side of this box was an opening through which a tube was passed, carrying a continual current of air washed and dried in sulphuric acid. Oxidation of the oil films commenced at once, and the amount of oxygen absorbed was determined at suitable periods, by weighing, the increase in weight giving this factor. This test was kept up for a period of twenty days.

A test was also made in the same manner with a

current of damp air passing into the box, to observe the relative oxidation under such conditions.

The experiments required an immense amount of labor and time, involving great care in the weighings, which were taken with the greatest accuracy. Charts of the results obtained have been made, to show the effect of the various driers, and they are presented herewith.

Linseed Oil and MnO_2 (Manganese) Dryer—Test No. 1

MnO_2%: 0.02%		0.05%	0.15%	0.25%	0.35%	0.45%	0.55%	0.70%	1.00%
Days	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain
1	0.08	0.11	4.16	——	3.21	3.46	3.27	3.01	2.76
2	0 16	5.88	4.48	——	3.63	4.01	3.70	3.51	3 18
3	0.21	6.79	4.61	——	3.83	4.31	——	3.91	——
4	——	——	4.64	——	——	——	——	——	——
5	3.01	6.84	——	——	4.13	4.68	4.10	3.91	3.99
6	8.00	——	4.88	——	4.37	——	4.51	4.32	4 13
7	8.58	6.92	4.90	——	4.48	——	4 61	4.52	4.23
8	9.06	——	5.03	——	4.55	5 23	4.77	4.62	4.44
9	——	——	5.12	——	4.63	5.40	4.94	4.79	4.51
10	9.07	6.89	5.18	——	4.81	5.47	——	4.98	4.73
11	9 15	7.03	——	——	——	——	——	——	——
12	——	——	——	——	4.98	——	5.45	5.33	5.22
13	9.22	7.17	——	——	5.25	6.00	5.60	5 42	5.33
14	9.25	7.18	5.55	——	——	——	——	——	——
20	——	7.21	5.81	——	5.84	6.70	5.94	5.84	5.77

Above percentages of drier reckoned to metallic content

Linseed Oil and MnO_2 (Manganese) Dryer—Test No. 2 (Check)

MnO_2%: 0.02%		0.05%	0.15%	0.25%	0.35%	0.45%	0.55%	0.70%	1.00%
Days	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain
1	——	3.12	4.42	3.86	——	3.19	2.98	3.27	2.56
2	——	6.15	4.73	——	——	3.51	3.28	3.70	2.96
3	0.28	6.29	——	4.12	3.72	——	3.39	3.71	3.15
4	3.83	6.32	4.75	4.21	3.87	3.61	3.58	4.05	3.43
5	6.64	——	4.84	4.23	3.94	3.73	3.65	4.21	3.56
6	8.61	——	4.87	——	4.08	3.81	3.78	4.35	3.73
7	9.07	6.35	5.00	4.41	4.18	3.91	3.85	4.54	3.87
9	9.25	6.39	5.16	——	4.44	4.11	4.21	4.63	4.26
11	——	——	——	4.63	4.59	4.36	4.31	5.07	4.46
16	——	6.43	5.30	4.91	4.83	4.72	4.71	5.40	4.87

Linseed Oil and PbO (Lead) Dryer

PbO %:		0.05%	0.10%	0.30%	0.50%	0.70%	1.00%	1.30%	1.60%	1.30%	1.60%
Days	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain
1	0.042	0.049	0.092	0.058	0.066	0.062	0.062	0.079	0.039	0.14	0.72
2	0.098	0.104	0.153	0.116	0.157	——	0.194	4.83	4.79	5.27	6.11
3	0.128	0.159	0.170	0.137	0.279	0.185	7.11	8.60	5.35	7.89	8.28
4	0.164	0.214	0.206	0.178	——	4.07	7.39	9.55	8.53	7.93	8.68
5	0 176	——	0.306	——	0.340	7.60	7.47	9.87	8.78	8.18	——
6	0.188	0.231	——	0.243	0.472	9.36	7.64	10.01	9.00	8.24	9.09
7	0.206	0.251	——	0.253	1.080	10.06	——	10.14	——	——	——
8	0.212	0.253	——	0.280	4.80	10.38	7.70	10.22	9.05	——	——
9	0 226	0.291	0.306	0.331	7.36	10.41	7.73	10.23	9.07	——	——
13	0.327	0.428	0.510	0.674	11.01	10.67	7.91	10.48	9.29	8.62	——
15	0.466	0.455	0.650	2.41	11.05	——	7.92	10.50	9.30	——	——
20	0.521	1.08	1.78	8.76	11.25	10.67	7.98	10.52	9.36	——	——

Linseed Oil and PbO (Lead) and MnO_2 (Manganese) Combination Dryer

PbO %: MnO_2 %:	.1 PbO .005 MnO_2	.3 PbO .015 MnO_2	.5 PbO .025 MnO_2	.7 PbO .35 MnO_2	.9 PbO .45 MnO_2	1.1 PbO .55 MnO_2	1.4 PbO .7 MnO_2
Days	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain	% Gain
1	0.026	0.061	0.055	0.022	0.16	0.11	3.06
2	0.094	0.087	0.143	0.16	5.21	6.28	3.37
3	0.118	——	0.17	4.23	7.63	8.31	3.74
4	——	0.11	0.23	7.36	8.87	9.20	4.02
5	0.120	0.12	0.29	9.04	9.13	9.37	4.17
6	0.17	0.13	1.44	9.88	9.26	9.51	4.34
7	0.21	0.18	4.65	10.11	9.28	——	4.45
11	0.30	0.26	10.03	10.35	9.61	9.85	5.11
12	——	——	——	10.45	9.66	——	——
13	0.35	0.54	10.37	10.51	9.67	10.03	5.33
18	0.49	3.43	10.38	10.62	9.68	——	5.73

Information to be Deduced from Tests: The following outline will present to the mind of the reader the most salient points which have been gleaned from these experiments, and which should give the manufacturer definite knowledge as to the best percentage of oxides to use either in boiled oil, paints or varnishes.

In the case of lead oxide, an increase in the percentage of lead oxide in the oil causes a relative in-

crease in the oxygen absorption, but when a very large percentage of lead has been added, the film of oil dries to a leathery skin.

In the case of manganese oxide, the increase in oxygen absorption on the first day is much more pronounced than is the case with lead oxides. Furthermore, the oxidation of manganese oils seems to be relative to the increase in manganese up to a certain period, when the reverse of this law seems to take place, and beyond a certain definite percentage of manganese, added percentages seem to be of no value. It was furthermore observed that the films dry to a brittle and harder skin than in the case of lead oxide. The oxygen absorption in the case of oils high in manganese has been noticed to be excessive in some cases, and the film of oil becomes surface-coated, drying beneath in a very slow manner, a condition that often leads to checking. The critical percentage where the amount of manganese appears to be most propitious and renders the greatest efficiency seems to be .02%. This critical percentage, as it may be termed, should not be exceeded, and any added amount of manganese has the effect of making the film much more brittle and causes the so-called "burning up" of the paint. The loading of paint with drier and the bad result therefrom is explained from the above results.

In the same way with lead driers, excessive amounts of lead oxide seems to have no beneficial effect on the drying of an oil, and when the percentage which seems to be the most beneficial, namely 0.5% lead oxide, is exceeded, the film is apt to become brittle.

Effects of Damp Atmosphere on Drying of Oils: Oils containing lead oxide driers are less influenced in their drying tendencies by conditions of moisture in the atmosphere than oils containing manganese, but frequently, however, the former dry much better in a dry atmosphere. As a general rule, varnishes rich in manganese dry more quickly in a dry atmosphere, while those containing small quantities dry more quickly in a damp atmosphere.

Oxide vs. Other Driers: It has been found as the result of many experiments that the form in which the metal is incorporated, e. g., whether as oxide or as borate, is immaterial, as far as the drying properties are concerned, and indeed the use of lead and manganese driers other than oxides is resorted to largely on account of the ease with which they can be introduced.

Products of the Oxidation of Linseed Oil: It was furthermore noticed in these tests that sulphuric acid, placed in dishes on the bottom of the large box in which the samples of oil were drying, were discolored and turned brown after several days, showing that the acid had taken up some material of a volatile nature that was a product of the oxidation.

Another curious feature of these tests was the development of a peculiar aromatic odor which was given off by the oils upon their drying in dry air. When the oils were dried in moist air, a rank odor resembling propionic acid was observed, and this led the observers to believe that a reaction was effected by the oxygen being absorbed, that caused the glycerine combined with the linoleic acid as linolein to split up

into evil-smelling compounds. It has been suggested that the oxygen first attacks the glycerine, transforming it into carbonic acid, water and other volatile compounds, which are eliminated before the oil is dried to linoxyn. Toch*, however, has shown that the drying of linseed oil gives off only very small percentages of carbon dioxide. Mulder has observed that in the process of linseed oil being oxidized, glycerine is set free, which becomes oxidized to formic, acetic and other acids, while the acid radicals are set free and are converted by oxygen into the anhydrides from which they pass by further oxidation into linoxyn.

Although we have found that a drier deteriorates in its drying power upon standing in an open vessel, such deterioration does not take place when the vessel is sealed. The writer believes that deterioration in air may take place as the result of the decomposition of certain lead or manganese glycerides which have been formed. The precipitation of so-called "foots" which is sometimes observed afterward is probably due to by-products of this decomposition, in the form of glycerinates and other organic compounds.

Auto-Oxidation and Peroxide Formation: The theory of auto-oxidation of linseed oil has been very ably treated by Blackler, whose experiments indicated that during the drying process the slow absorption of oxygen was, at a critical period, followed by a rapid absorption which he attributes to the presence of peroxides which accelerate oxidation. The materials produced by this peroxide formation may act as catalyzers and accelerate the formation of more peroxide.

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* The Chemistry and Technology of Mixed Paints. Toch, p. 89. D. Van Nostrand Co., New York.

Lead and manganese oxides may also be oxidized to peroxides by the action of oxygen and in this event might act as very active catalyzing agents or carriers of oxygen. Blackler's statement that the presence of driers do not increase, but have a tendency to decrease the initial velocity of oxygen absorption, has been confirmed by our experiments, but we have noticed throughout these tests the accelerative action of driers at later periods.

Other Drying Tests of Interest: Some most interesting results were secured by taking extremely fine copper gauze and dipping it into linseed oil. The adhesion of the oil to the copper caused a film to form in the minute spaces and remarkable drying action was observed when this oil-coated copper gauze was exposed to oxidation. The effect of the copper in this case, or any superficial coating of copper oxide which may have been present on the metal, undoubtedly affected this result to some extent. It has been found that metallic lead is even more efficient than copper in this respect, but this may be due to the action of free acid in the linseed oil, forming lead linoleates, products that greatly accelerate drying. Another interesting experiment was made by taking pieces of gauze cloth and immersing in linseed oil. After the excess oil had been removed, by pressing, the cloth was again weighed to determine the amount of oil used for the experiment. The increase in oxygen absorption in this case was very rapid and the result obtained confirmed the results in the other experiments.

In order to secure a more evenly distributed state

of the oil, tests were conducted by saturating pieces of stiff blotting papers and after exposure weighing as usual. While these conditions appear favorable for quick drying, it is yet premature to make any statements concerning the results.

The Action of Light on the Drying of Oils: The influence of light on the drying of oils is unquestionably a potent one. The practical painter knows that a certain varnish will dry quicker when exposed to the light than when in the dark.

Chevreul was one of the first pioneers in this field of research to observe the effects of colored lights on drying, and he claimed that oil exposed under white glass dried more readily than that exposed under red glass which eliminates all light of short wave lengths.

Genthe obtained interesting results in the drying of oil submitted to the effects of the mercury lamp. Oxidation without driers was effected probably through the formation of peroxides. In commenting on this subject, Blackler gives a description of the use of the Uveol lamp, which is similar to the mercury lamp, but has instead of a glass casing which cuts off the valuable rays, a fused quartz casing which allows their passage. In a recent paper Blackler* says: "The drying oils obtained by this method have particularly valuable properties. When applied the oil dries rapidly and instead of forming a skin a complete solidification takes place, giving a brilliant non-sticky coating, which resembles varnish in appearance. This glowing description may be somewhat too laudatory,

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*Dr. M. B. Blackler. "The Use and Abuse of Driers." Paper read before the Paint and Varnish Society, London, Eng., Sept. 9, 1909.

but nevertheless I think that a distinct advance has been made by the discovery of this process.

"The operation is carried out as follows:

"A vat illuminated with 20 Uveol lamps is charged with 1000 kilos of oil warmed to 80 degrees C. Oxygen in a finely divided condition is then passed through the oil; the energy of the reaction is sufficient to keep up the temperature without the application of external heat."

Boiled Oil and the Drier Question: In the boiling of linseed oil, by certain processes the oil is heated to 250 deg. and manganese resinate is incorporated therein. It goes into solution quite rapidly. In other processes the oil is heated to 400 deg. or over, and manganese as an oxide is boiled into the oil. Although it is unsafe to say that a small percentage of rosin such as would be introduced by the use of resinate driers, is not harmful, yet it appears that this process should give a good oil, inasmuch as we have found that no matter in what way the manganese is added to the oil, whether as a resinate, borate or oxide, the same drying effect is noticed in every case where the percentage of manganese is the same. It is the opinion of some, however, that the resinate driers are not as well suited for durability as oxide driers. If, therefore, a boiled oil is found to contain on analysis a small percentage of rosin (less than 0.5 per cent.), it should not be suspected of adulteration. Practical tests, however, should be made with it along with an oil made with an oxide drier before pronouncing on its value. The temperature of the oil when heated to incorporate the oxides is very important, and the factors previously mentioned should be carefully noted by the manufacturer.

Percentage of Drier Most Efficient: Inasmuch as the addition of driers of any type to linseed oil lessens the durability of the film, it is more practical to use the smallest amount of drier that will serve the purpose desired, that is, to set the oil up in a paint to a hard and dry condition which will not take dust and which will stand abrasion.

To sum up the results of our investigations and place before the paint manufacturer and master painter material for his guidance, the following data will be of value.

Efficient results may be obtained with .5% lead or with .05% manganese in linseed oil or with a combination of .5% lead and .02% manganese.

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Petroleum and Its Products—2 Vols. —*Sir Boverton Redwood*

A Treatise on its Distribution, Occurrence, Physical and Chemical Properties, Refining and Uses

Handbook on Petroleum —*Thomson Redwood*

A Treatise on the Industrial Use of its Products.

Simple Methods for Testing Painters' Materials —*A. C. Wright*

Letters to a Painter —*Ostwald-Morse*

On the Theory and Practise of Painting

Iron Corrosion and Anti-Corrosive Paints —*L. E. Andes*

Dictionary of Chemicals and Raw Products —*G. H. Hurst*

Used in the Manufacture of Paints, Colors, Varnishes and Allied Preparations

Oil Colors and Printers' Inks —*L. E. Andes*

A Practical Handbook Treating of Linseed Oil, Boiled Oil, Paints, Artists' Colors, Lamp Black, and Printers' Inks

Manufacture of Mineral and Lake Pigments —*J. Bersch*

Containing Directions for the Manufacture of All Artificial Artists' and Painters' Colors, Enamel Colors, Soot and Metallic Pigments

Chemistry of Paints and Painting —*A. H. Church*

Painters' Laboratory Guide —*G. H. Hurst*

A Handbook on Paints, Colors and Varnishes

Pigments, Paints and Painting —*A. T. Terry*

A Practical Book for Practical Men

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Mixed Paints, Color Pigments and Varnishes —*Holley and Ladd*

Chemical Technology and Analysis of Oils, Fats and Waxes, Vols. 1 and 2 —*J. Lewkowitsch*

Chemistry and Technology of Mixed Paints —*M. Toch*

Chemistry of Paint and Paint Vehicles —*Hall*

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The Microscope —*S. H. Gage*

A Treatise on Color Manufacture —*Zerr & Rubencamp*

Outlines of Qualitative Chemical Analysis —*Gooch & Browning*

Manufacture of Paint —*J. Cruikshank Smith*

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The Chemistry of Pigments —*Parry & Coste*

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Notes on Lead Ores —*Jos. Fairie*

Their Distribution and Properties

Technology of Paint and Varnish —*A. H. Sabin*

Oil Chemists' Handbook —*Hopkins*

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Chemiker-Kalendar—1908.

Principles of Reinforced Concrete Construction —*Turneaure & Maurer*

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Table of Minerals —*Samuel Lewis Penfield*

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Notes on the Structure of Paint Films —*L. S. Hughes*
The Lead and Zinc Pigments —*C. D. Holley*

Transactions of the American Electrochemical Society, 1909.

Report of Tariff Committee, Paint Manufacturers' Association of the United States, 1909.

Bulletins of the Census Bureau.

Paints for Steel Structures —*Houston Lowe*
The Chemistry of Photography —*Raphael Meldola*

Pamphlets

- The Corrosion of Iron —*A. S. Cushman*
- Corrosion of Fence Wire —*A. S. Cushman*
- Some Technical Methods of Testing Miscellaneous Supplies —*P. H. Walker*
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Periodicals:

- Journal of Industrial and Engineering Chemistry
- Journal of the American Chemical Society
- Chemical Abstracts
- Oil, Paint and Drug Reporter
- The Decorator
- Drugs, Oils and Paints
- The Painters' Magazine
- The American Paint and Oil Dealer
- One Thousand More Paint Questions Answered.

Publications of the Scientific Section

BUREAU OF PROMOTION AND DEVELOPMENT

PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

Bulletin Number

Preliminary Booklet—Addresses on Paint, Delivered Before the Michigan Chapter, American Institute of Architects, 1907. (*Out of print.*)

1—Tables of White Pigments and Vehicle—Standard Nomenclature.

2—Standard Can Sizes Recommended to Paint Manufacturers.

3—First Report on the Test Fences Erected by the Scientific Section. (*Out of print.*)

4—Methods for the Analysis of the Vehicle Constituents of Paint. (Out of print.)

5—Tests Upon the Corrosion of Iron to be Conducted by the Scientific Section. (*Out of print.*)

6—First Annual Report of the Scientific Section.

7—Preliminary Report on Steel Test Fences.

8—Report of Committee "E" on Preservative Coatings for Iron and Steel. (*Out of print.*)

9—Recent Technical Developments in Paint Manufacture.

10—Protective Coatings for Conservation of Structural Material.

11—The Corrosion of Iron and Steel. *By Alfred Sang.* (*Out of print.*)

Bulletin
Number

12—The Function of Oxygen in the Corrosion of Metals. *By William H. Walker.*

13—Protective Coatings for Steel and Iron. *By Robert S. Perry.* (*Out of print.*)

14—Coatings for the Conservation of Structural Material. (*Out of print.*)

15—Protective Coatings for Structural Material. *By R. S. Perry.*

16—First Annual Report on Wearing of Paints Applied to Atlantic City Test Fence.

17—First Annual Report on Wearing of Paints Applied to Pittsburg Test Fence.

18—First Annual Report on Atlantic City Steel Test Fence.

19—Laboratory Study of Panels on Atlantic City and Pittsburg Test Fences.

20—Concrete Coatings. *By H. A. Gardner.*

21—A Brief Talk on Paints. *By Henry A. Gardner.*

22—Annual Report for 1909.

Preliminary Bulletin—Second Edition—Physical Characteristics of a Paint Coating. *By R. S. Perry.*

23--The Theory of Driers, Etc.

24—Some Iron Oxides and Their Values.

25—Report on Examination of North Dakota Test Fences.

Bulletin No. 24

SOME IRON OXIDES AND THEIR VALUES

SCIENTIFIC SECTION—EDUCATIONAL BUREAU
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Some Iron Oxides

and

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SOME IRON OXIDES AND THEIR VALUES

Close Inspection Advisable: The object of this paper is to present to the paint manufacturer information regarding the composition, strength and color value of those iron oxides finding a wide application upon the American market as painting pigments. Paint manufacturers generally have their own selected grades of oxide, adopted as standards, and obtained from the same source yearly. Their value, however, in some cases may not have been as closely considered as other factors in their purchase. Comparison with the various grades shown in this book will probably lead in some instances to closer inspection.

Source and Methods of Production: Technical literature is replete with information about the source, production and methods of manufacture of iron oxide pigments. The manufacturer is, therefore, generally possessed of a wide knowledge on this subject, and no attempt will be made to bring the matter forth in detail. The following brief paragraphs, however, will not be out of place in commenting on the subject.

Oxide of iron is found in nature in

three forms: As a greenish white oxide (ferrous oxide), as a bright red or brown oxide (ferric oxide), and as a black oxide (magnetic or ferroso-ferric oxide). The latter is a combination of both the ferrous and ferric oxide, and its difference in color to either of these oxides is analogous to the difference in color shown by red lead (lead tetroxide) which is a combination of yellow litharge (monoxide of lead) and brown oxide (lead dioxide).

The iron oxides are prepared for use by grinding in ball, edge runner, and stone mills, to the proper fineness, afterward elutriating, when it is desired to obtain a very fine product. These oxides are termed purple oxides, scarlet oxides, bright red oxides, Indian reds, and other names, according to the shade. The oxides are also obtained artificially by heating green vitriol or copperas (sulphate of iron) in muffle furnaces or kilns, and other types of furnaces. When these products are heated, they give off their acid content, leaving a bright red oxide. Washing of this pigment removes most of the free acid that heat has failed to disengage.

The neutralization of pickling liquors containing sulphate of iron, with lime water, produces a double precipitate of calcium sulphate and ferric hydroxide which, when filtered off and burned, also produces

an oxide containing various amounts of sulphate of lime. This material is generally called Venetian red because of its shade. Pyrites cinder is sometimes used as an oxide, and, when rich in copper, the latter is first removed by solution in acid and precipitation in the metallic iron, the acid liquors being subsequently treated like the pickling liquors for the production of Venetian red.

Color Value, Shade, Fineness and Other Properties: Although the coloring value of an iron oxide, one of the qualities most looked for, is generally proportional to the iron oxide content, the shade and tone are generally dependent upon the form in which the oxide occurs, whether as ferrous or ferric oxide. The degree to which the oxide has been burnt, if of an artificial source, also affects the shade.

The coloring value is best determined by admixture of the sample under test with a percentage of zinc oxide or other white base pigment, until a definite shade or tint has been obtained. The amount of iron oxide necessary to produce this standard tint may then be interpolated into percentage strength in coloring value.

For purposes of comparison, however, we have made our tests on the coloring values of the oxides described in this booklet, by diluting each with one hundred parts of zinc oxide, the resulting color being painted out on strips of paper.

The tone or color of a pigment is subject to so many confusing terms that those given by one chemist may not be considered fair by another. Different pigments placed near together in small heaps often show wide divergence in color. When such pigments are ground separately in oil, with slab and muller, then spread out to a smooth even surface on a slide of glass, the color differences often appear even greater, especially when one sample contains inert pigments that are transparent in oil.

Various methods have been used to obtain an absolute determination of color. One of the most successful pieces of apparatus for this work is the Tintometer, an instrument having a set of standard color glasses, by the use of which any color, shade or tint, may be determined in terms of the standard, and thus recorded for future use. This instrument is of great value for the preservation of records of colors which are apt to fade under the action of light.

In this book is shown the actual color of each pigment ground in oil and painted out on paper. The color, brilliancy and body of the pigments vary considerably, as will be seen by comparing the samples.

Fineness may be determined absolutely with a microscope. Another useful method of determining the comparative fineness of two samples of the same pigment, is by suspension of the pigments in a known volume

of water in glass cylinders. This is called the settling test. The pigment remaining in suspension the longer period is evidently the finer, if the gravity of each is approximately the same. The fineness of the pigments shown in this book, however, was determined by submitting each sample to grinding in oil with a spatula on a glass plate. The observations of the operator are recorded in each instance.

Value for Iron and Steel Paints: The relative inhibitive properties of the various oxides is also reported upon. The usual steel plate test, together with the aerating apparatus shown in cut, was used in this determination. Ten cubic centimeters of pigment and 50 c. c. of distilled water, together with a carefully weighed steel plate, 2 inches x 1 inch, were placed in each bottle. Air was conducted through the series for a period of one week. The pigment and rust was brushed from the plates after the test and the loss of weight through corrosion determined by reweighing. This amount was calculated to percentage loss.

INHIBITIVE TESTS ON IRON OXIDES

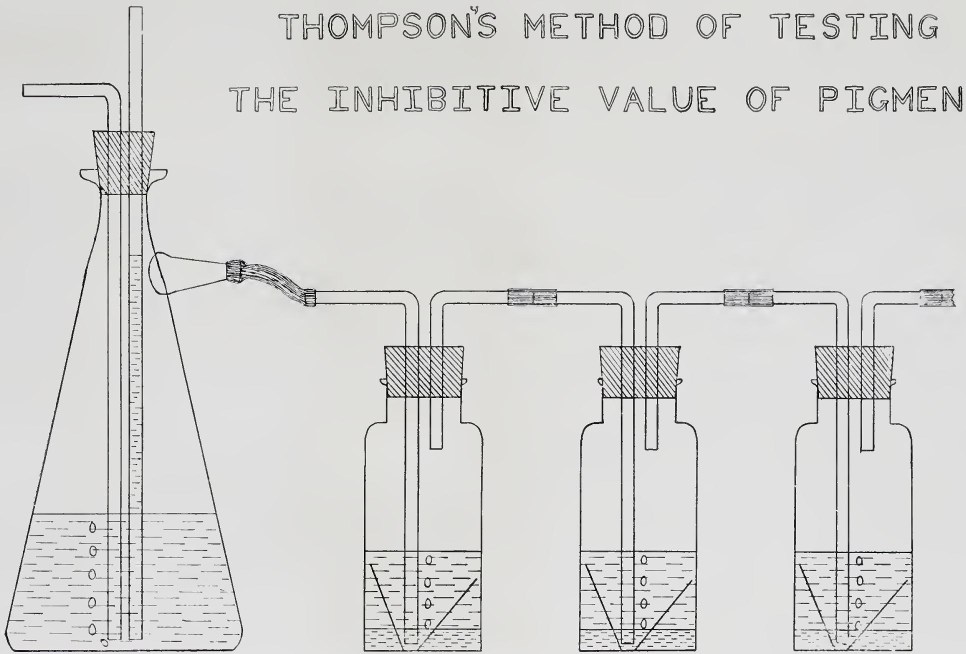
Oxide Inhibitive Test *One Week*

Number	Loss on 5 g. plate	Per cent. loss
8	0.102	2.05
27	0.103	2.05
4	0.070	1.40
18	0.0715	1.43
13	0.95	1.92
11	0.0775	1.55
3	0.0785	1.57
2	0.0795	1.59
5	0.0835	1.67
28	0.0960	1.92
17	0.0970	1.94
26	0.0980	1.96
1	0.103	2.06
10	0.104	2.08
0	0.118	2.36
7	0.083	1.65
16	0.1325	2.65
20	0.1375	2.75
15	0.1475	2.95
14	0.1745	3.49
24	0.201	4.02
25	0.206	4.12
23	0.11	2.3
12	0.380	7.60

These tests were conducted in the Cushman-Thompson apparatus as herein described. See cut.

THOMPSON'S METHOD OF TESTING

THE INHIBITIVE VALUE OF PIGMENTS.



No. 10

RED OXIDE

Analysis:

Iron Oxide	Ferrous Oxide (FeO)	1.44%
	Ferric Oxide (Fe_2O_3)	60.25%
Alumina (Al_2O_3)		5.41%
Insoluble (SiO_2 Silicates)		15.78%
Water Loss on Ignition (CO_2 in $CaCO_3$ deducted)		3.45%
Calcium Sulphate ($CaSO_4$)		.78%
Calcium Carbonate ($CaCO_3$)		9.48%
Phosphoric Oxide (P_2O_5)		1.28%
Undetermined		2.13%
		100.00%

Color: Brownish Red.
Grinding: Gritty.

COLOR

100% Pigment in Oil

REDUCED COLOR

99% Zinc Oxide; 1% Pigment in Oil

No. 11

VENETIAN RED

Analysis:

Iron Oxide	Ferrous Oxide (FeO)	.30%
	Ferric Oxide (Fe_2O_3)	34.08%
Alumina (Al_2O_3)		2.20%
Calcium Sulphate ($CaSO_4$)		52.60%
Calcium Carbonate ($CaCO_3$)		4.14%
Insoluble (SiO_2)		3.39%
Water + Loss on Ignition		3.24%
Undetermined		.05%
		100.00%

Color: Bright Red-Brown.
Grinding: Very Fine.

No. 12

B OXIDE

Analysis:

Iron Oxide	Ferrous Oxide (FeO)	0.58%
	Ferric Oxide (Fe_2O_3)	67.68%
Alumina (Al_2O_3)		2.48%
Water + Loss on Ignition		1.35%
*Barium Sulphate ($BaSO_4$)		18.50%
Barium Chloride ($BaCl_2$)		6.57%
Insoluble (SiO_2)		1.97%
Undetermined		.87%
		100.00%

Color: Dark Red-Brown.
Grinding: Very Gritty.

*Remarks: Unusual presence of Barium Chloride and its large percentage may be due to attempt to get rid of Sulphuric Acid and insufficient later washing.

No. 24

MICACEOUS BLACK OXIDE

Analysis:

Iron Oxide	Ferrous Oxide (FeO)	2.02%
	Ferric Oxide (Fe_2O_3)	86.27%
Alumina (Al_2O_3)		2.04%
Water		.07%
Insoluble (SiO_2)		9.50%
Undetermined		.10%
		100.00%

Color: Dark Gray Tone.
Grinding: Very Gritty.
Character: Micaceous, flaky; resembling graphite.

No. 25

BLACK OXIDE

Analysis:

Iron Oxide	Ferrous Oxide (FeO)	33.12%
	Ferric Oxide (Fe_2O_3)	57.12%
Carbon Dioxide (CO_2) combined		7.42%
Alumina (Al_2O_3)		1.44%
Water		.53%
Undetermined		.37%
		100.00%

Color: Jet Black.
Grinding: Very Fine.

No. 26

RED OXIDE

Analysis:

Iron Oxide	Ferrous Oxide (FeO)	0.57%
	Ferric Oxide (Fe_2O_3)	84.16%
Alumina (Al_2O_3)		2.00%
Calcium Sulphate ($CaSO_4$)		5.00%
Calcium Carbonate ($CaCO_3$)		4.02%
Insoluble (SiO_2)		.63%
Water (combined uncombined)		3.17%
Undetermined		.45%
		100.00%

Color: Deep Red.
Grinding: Fine.

COLOR

100% Pigment in Oil

REDUCED COLOR

99% Zinc Oxide; 1% Pigment in Oil

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Chemiker-Kalendar—1908.

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Periodicals:

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Publications of the Scientific Section

BUREAU OF PROMOTION AND DEVELOPMENT

PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

Bulletin Number

Preliminary Booklet—Addresses on Paint, Delivered Before the Michigan Chapter, American Institute of Architects, 1907. (*Out of print.*)

1—Tables of White Pigments and Vehicle—Standard Nomenclature.

2—Standard Can Sizes Recommended to Paint Manufacturers.

3—First Report on the Test Fences Erected by the Scientific Section. (*Out of print.*)

4—Methods for the Analysis of the Vehicle Constituents of Paint. (Out of print.)

5—Tests Upon the Corrosion of Iron to be Conducted by the Scientific Section. (*Out of print.*)

6—First Annual Report of the Scientific Section.

7—Preliminary Report on Steel Test Fences.

8—Report of Committee "E" on Preservative Coatings for Iron and Steel. (*Out of print.*)

9—Recent Technical Developments in Paint Manufacture.

10—Protective Coatings for Conservation of Structural Material.

11—The Corrosion of Iron and Steel. *By Alfred Sang.* (*Out of print.*)

Bulletin
Number

12—The Function of Oxygen in the Corrosion of Metals. *By William H. Walker.*

13—Protective Coatings for Steel and Iron. *By Robert S. Perry.* (*Out of print.*)

14—Coatings for the Conservation of Structural Material. (*Out of print.*)

15—Protective Coatings for Structural Material. *By R. S. Perry.*

16—First Annual Report on Wearing of Paints Applied to Atlantic City Test Fence.

17—First Annual Report on Wearing of Paints Applied to Pittsburg Test Fence.

18—First Annual Report on Atlantic City Steel Test Fence.

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21—A Brief Talk on Paints. *By Henry A. Gardner.*

22—Annual Report for 1909.

Preliminary Bulletin—Second Edition—Physical Characteristics of a Paint Coating. *By R. S. Perry.*

23--The Theory of Driers, Etc.

24—Some Iron Oxides and Their Values.

25—Report on Examination of North Dakota Test Fences.

Special Bulletin—Scientifically Prepared Paints and Laws Governing Their Manufacture. *By Henry A. Gardner.* (*In press.*)

Bulletin No. 25

1909

Report on Examination of North Dakota Test Fences

Inspector Examining Surface of Panels with Magnifier

SCIENTIFIC SECTION—EDUCATIONAL BUREAU

HENRY A. GARDNER, Director

PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

3500 Grays Ferry Road, Philadelphia, Pa.

1909 Report on Examination of North Dakota Test Fences

SCIENTIFIC SECTION

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BUREAU OF PROMOTION AND DEVELOPMENT

PAINT MANUFACTURERS' ASSOCIATION

OF UNITED STATES

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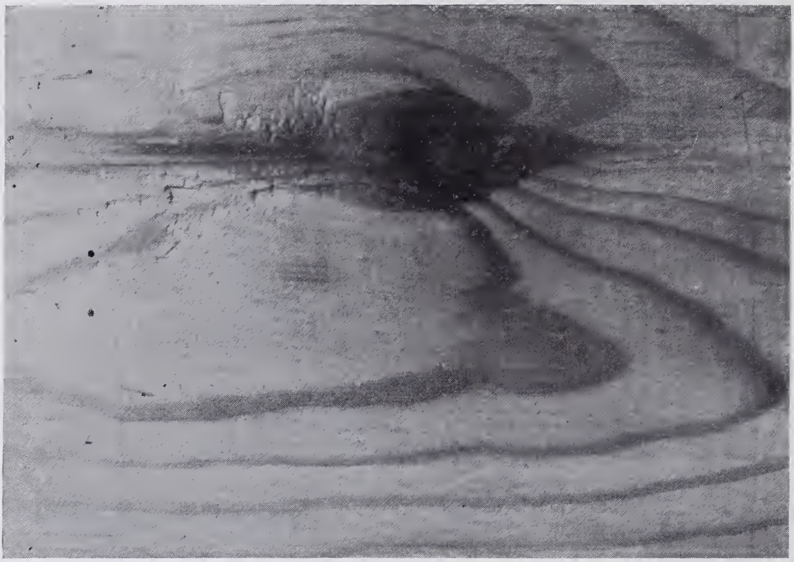
PREFACE

THIS report is a duplicate of that made by the Scientific Section to Dr. E. F. Ladd, Director of the Agricultural Experiment Station at the North Dakota Agricultural College, Fargo, North Dakota, for publication, together with the reports of the other committees that inspected the North Dakota Test Fences.

This report contains the findings of the inspectors chosen by the Bureau of Promotion and Development to examine the North Dakota Fences, and will probably prove of especial interest to those manufacturers who have closely followed the Atlantic City and Pittsburg Test Fence reports, as the same methods were used throughout in the inspection of all three fences.

H. A. GARDNER
Director Scientific Section



Typical Sample of Hard Pine Trim Board Showing Knot and Sappy Grain.

Pine Weatherboarding Showing Knots and Grain.

General Summary of Report

Committee Representing Paint Manufacturers' Association of the United States

Henry A. Gardner, Director Scientific Section, Bureau of Promotion and Development, Paint Manufacturers' Association of U. S.

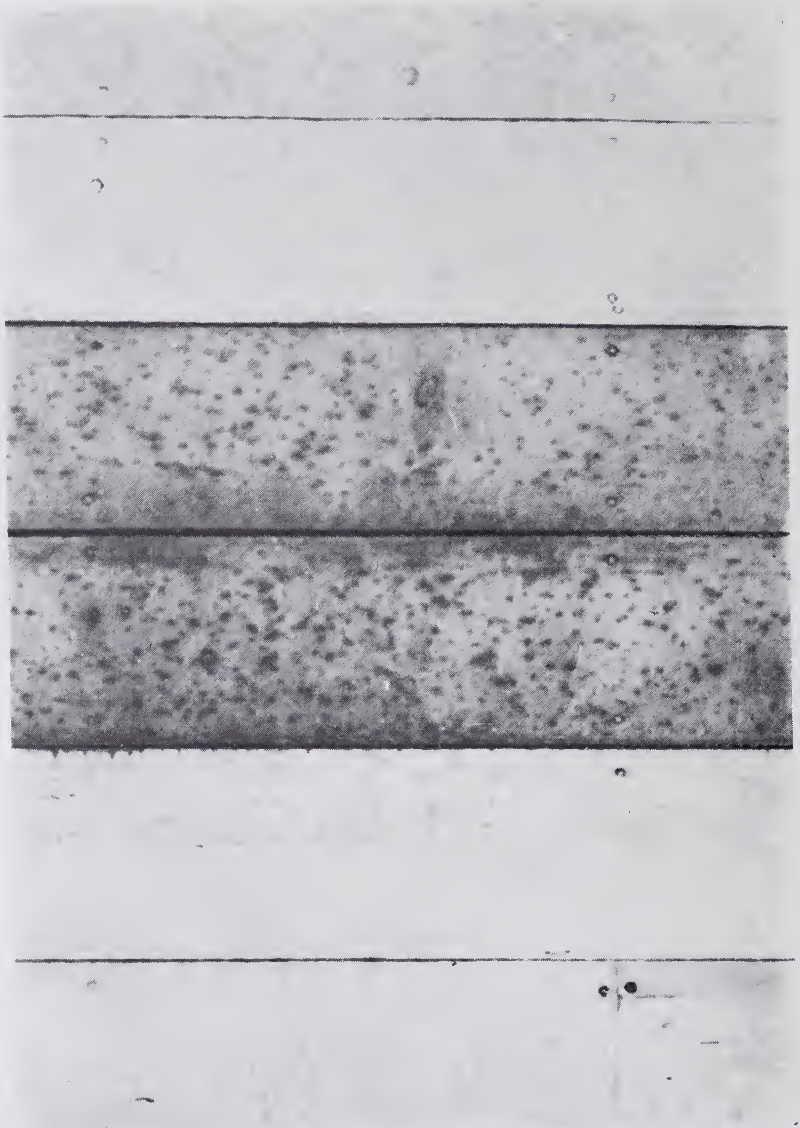
George Butler, Master Painter; Charles Macnichol, Master Painter

An inspection of the original test fence, erected and painted by the College, on the grounds of the North Dakota Experiment Station, at Fargo, was made by this committee on the 19th and 20th of November, 1909. This fence was erected in 1906 and painted with commercial paints, procured in the open market. The east side of the fence was built of soft pine and cedar weather-boarding, such as is almost universally used on houses, and presenting a very good surface for test purposes, while the west side was largely built of flat trimmed boards of hard pitch pine which, unfortunately, contained knots, pitch pockets and uneven surfaces, causing to a greater or lesser extent cracking, scaling and bad general results on all paints applied thereto.

The fences built in 1907 and 1908 at the suggestion of the Paint Manufacturers' Association, were inspected on the 20th, 21st and 22nd of November, 1909, and the detailed results of the inspection of all these fences follow this report. The same general conclusions as to the woods represented in the 1906 fence also apply to the 1907 and 1908 fences, and because of the general bad quality of wood used on the western exposure of all fences, the detailed reports were made only from an examination of the eastern side of the fences, both on cedar and soft pine.

The following general summary of the inspection and its results applies to all the test fences on the grounds of the college and is the unanimous conclusions drawn by the inspectors from this work.

Non-absorbent woods, difficult to penetrate, such as those on the west side of the fences, would undoubtedly have given much better results had they been painted with paints properly reduced to suit the



Hail-stone Effect, West Side of 1907 Test Fence.

nature of the wood. This treatment seems to have been overlooked in the North Dakota tests, and the painting of the hard pine boards was done with the same consistency of mixtures and same reductions as upon soft pine. Scaling, of course, resulted. One of the chief purposes of the fences, however, was to study the different types of wood, and compliance with this desire resulted in the bad conditions herein noted. It has been shown in many other field tests that adherence of paints to hard wood surfaces can be obtained only by causing the priming coat to become amalgamated with the woody fibre, by the use of a large percentage of volatile diluent (turpentine, benzine, asphaltum spirits, etc.) to secure penetration. If such treatment is omitted, failure soon results, as was evidenced by the uniformly bad conditions presented by the paints on the hard pine panels.

During July, 1908, a violent hailstorm occured in Fargo, and left its impression on nearly every wooden structure; in many cases deep dents being made into the wood. The west side of the test fences, which received the most injury from this storm, was covered with these dents over almost its entire surface, causing cracks in the form of concentric rings to appear on the abraded paint coatings. When these abraded surfaces are to be repainted, allowance should be made at future inspections for the disturbing influence of the cracking caused by the abrasions, and the effect they will produce upon subsequent coatings of paint. The bad condition of the wood, improper method of applying primary coat, combined with the hailstorm effect, on the painted surfaces on the west side of the fences, were undoubtedly responsible for the universal failure of the paints thereon, and, for these reasons, the west side was eliminated from the detailed inspection, only general observations of these tests being made. These general observations, however, showed that paints Nos. 6 and 8 on the 1906 fence, and paints Nos. 8, 10 and 13 on the 1907 fence proved the most satisfactory on the western exposure.

Ochre was tried out as a priming coat on several formulas, but it was found to be most unsatisfactory, affecting the subsequent coats of paint and causing early failure, as evidenced by broad checking, discoloration and general bad condition. These conditions also apply to those panels on the 1908 fence coated with shellac as a primer.

The colored formulas in every case showed a great superiority over the same paints in white untinted, and demonstrated that a percentage of color has a wonderful influence on the preservation of the paint coating, reducing chalking, checking and general disintegration. This condition is probably due to the reinforcing value of the color pigments used.

It is safe to state that the combination formulas tinted yellow were of better appearance than the corroded white leads tinted yellow, the latter appearing quite dark in many cases.

Hail-stone Abrasions on House Repainting Tests.

The wearing of the paints made solely from white lead and zinc oxide seemed to indicate that a percentage of a third pigment, of an inert nature, would have been beneficial.

The high type mixtures of pigments containing lead and zinc, with moderate percentages of inert pigments, on good wood, were in most excellent general condition; in fact, much superior to the single pigment paints. Their surface exhibited only minor checking and moderate chalking with good maintenance of color, and presenting surfaces well adapted to repainting.

The sublimed white lead was in fair condition, with very little checking, and offering a fair repainting surface. The corroded white lead was somewhat whiter than the sublimed white lead, but a careful observation of the surface of the corroded lead revealed deep checking.

It was clearly demonstrated, however, that in climates of the North Dakota type white lead alone is not entirely satisfactory. The addition of zinc oxide to white lead forms paint that has proven much superior to the white lead alone.

It was conclusively demonstrated that mixtures of white lead and zinc oxide, properly blended with moderate percentages of reinforcing pigments such as asbestine, barytes, silica and calcium carbonate, have proved most satisfactory from every standpoint, and are superior to mixtures of prime white pigments not reinforced with inert pigments.

The white leads painted out on the 1908 fence exhibited different degrees of checking, the mild process lead and sublimed white lead which presented the best surfaces, were free from checking, while the old process leads seemed to be showing very deep and marked checking, even after one year's wear.

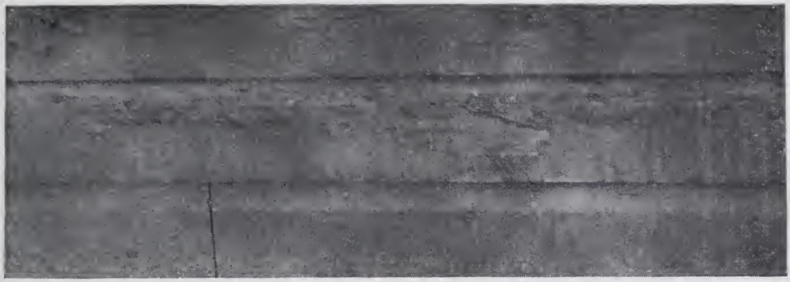
As before stated, we believe that a serious mistake was made on the test fence, in painting out the leads and other formulas on the various woods without any special attention to reduction to suit the nature of the wood, thus accounting largely for the difference of the wearing of the paints on the different woods.

The reduction of the white leads especially was to be criticised in these tests, in many cases too much oil and not sufficient turpentine being present to cause penetration.

The application of paint to cedar was satisfactory in most all cases and this wood showed much better results than the other woods upon the fences. The exudation of resinous pitch on the hard pine was extremely serious, in some cases coming through the paint in large streaks, causing bad results.

It is to be regretted that the house repainting tests which were conducted are of no special value, inasmuch as no information is on file as to the composition of the old paints originally on the houses before the application of the test paints. Imperfections in the old coat-

Peculiar Crystallization Effect on Section 41. New Special Fence Paint Applied During Cold Weather.



Rosin Exudations on Hard Pine Throwing Off Paint on House Tests

ing, such as excessive chalking, deep checking, scaling, rosin exudations, etc., affected the subsequent coats in such a manner as to prevent any knowledge of where the new and old paint troubles began. The committee, therefore, omitted a detailed inspection of such tests.

Examination of the three houses which were painted over new wood showed results which correspond with the results obtained from the fence tests. That is, they showed the ultimate value of high type mixtures of several pigments over one pigment alone. These tests seem to indicate that very good results can be secured from most of the paints sold in North Dakota. If the consumer or householder would exercise more care in the selection of wood and preparation of surfaces, with due regard to the proper reduction for various coats, more satisfactory results would be obtained.

From an examination of certain paints on the 1908 fence, containing petroleum spirits, it would appear that this paint thinner is of value, and in the face of conditions such as are presented by the present scarcity of turpentine, the use of petroleum spirits in moderate quantity would be justified.

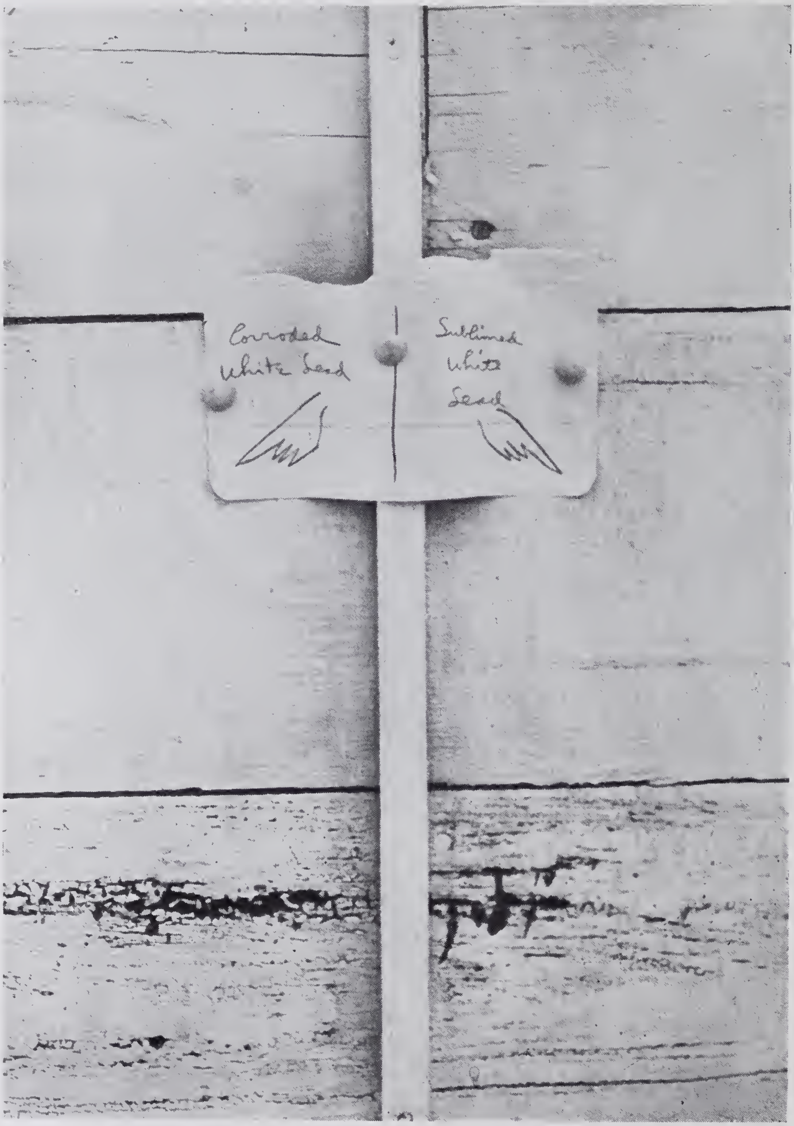
It appears to the inspectors, from a digest of the various field tests which have been made at Atlantic City, Pittsburg and North Dakota, that certain high type combination formulas have proved satisfactory in all three climates, and seem to demonstrate that such paints would prove of value in any part of the country.

(Signed) HENRY A. GARDNER, Director.
Scientific Section, Paint Manufacturers' Association of the U. S.

(Signed) GEO. BUTLER, Official Painter,
Atlantic City Test Fence.

(Signed) CHAS. MACNICHOL, Master Painter.

CORRODED WHITE LEAD SUBLIMED WHITE LEAD



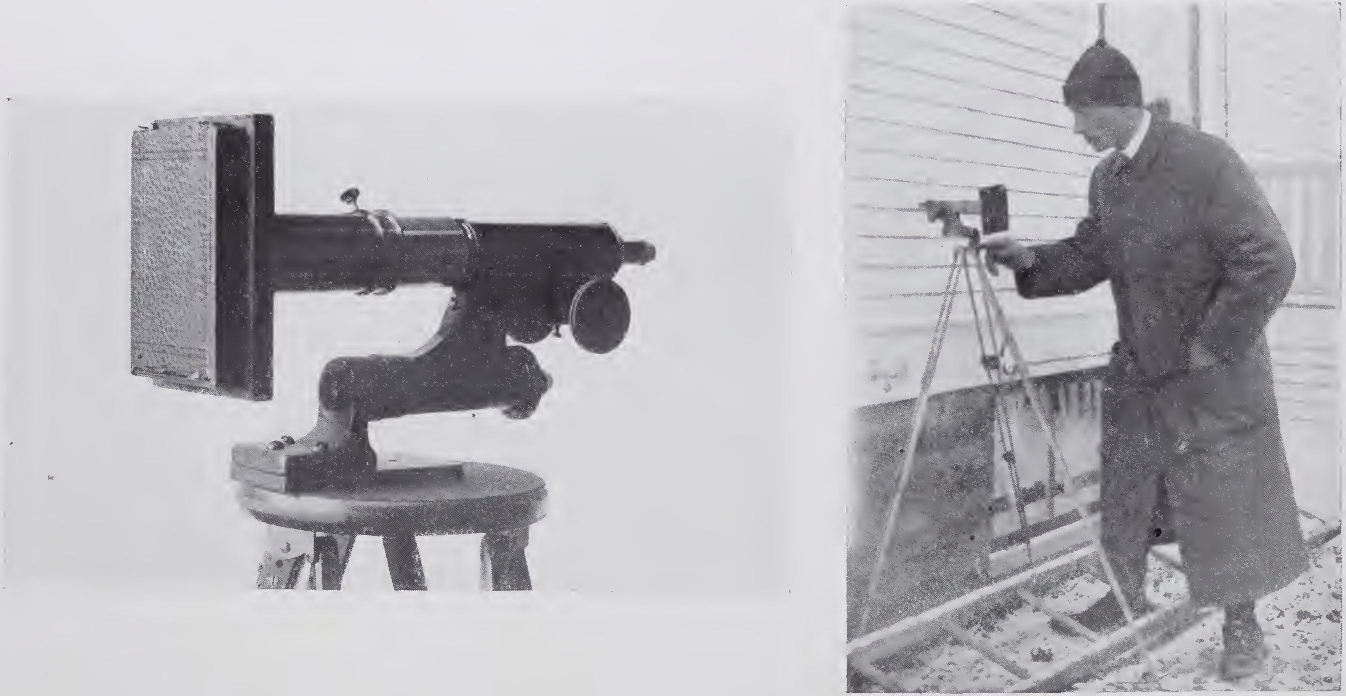
Condition of Two White Leads on Two Grades of Wood.

Fargo, North Dakota, Nov. 22, 1909.

The photographs and microphotographs of the various painted surfaces upon the houses and test fences, which were taken by Mr. H. A. Gardner, were carefully selected as representative and typical, and they present a fair criterion of the wearing of the various paints inspected.

(Signed) GEO. BUTLER,
Official Test Fence Painter, Master House Painters & Decorators' Association of Philadelphia.

(Signed) CHAS. MACNICHOL,
Master Painter, Washington, D. C.



Photomicrographic Apparatus and Method of Use.

DEFINITION OF TERMS USED IN DETAILED REPORT OF INSPECTION.

In the detailed inspection the term "Chalking" is used to define that condition of the paint film which indicates that the vehicle has disintegrated to some extent, thus exposing the pigment and allowing its removal when slight pressure of any object is brought to bear. It has been considered that a paint which chalks moderately would afford a better repainting surface than one in which the chalking had not taken place or in which the chalking was excessive.

By "Checking" is meant that condition of the painted surface that shows upon examination openings or cracks, possibly resulting from brittleness. There are several forms of checking: Surface Checking, on the outer coating of paint, which is not very dangerous; Fine Matt Checking, which is the initial state of checking leading to deeper checking; and Coarse and Deep Checking. Every pigment seems to show a difference in its characteristic form of checking. For a detailed study of this subject, see Bulletin No. 19, Scientific Section, Paint Manufacturers' Association.

By "Hiding Power" we mean to indicate the value of the paint in covering up the wood.

By "Color" we mean to define that condition of the paint which indicates whether the original color has been maintained. On white paint discoloration and darkening often result. On gray and yellow fading often takes place. This is all noted in the detailed report.

By "Condition for Repainting" we refer to the general condition of the paint to receive subsequent coats of paint without bad effect.

Gloss has not been reported in any of these tests, as an almost absence of this condition was noted on all formulas on the 1906 fence and almost entire absence on the 1907 fences.

Hardness was not reported on, as it is felt that at present no accurate method of reporting hardness is applicable in field inspection work.

Other conditions, such as washing, etc., which are sometimes reported upon, were covered in the detailed report when found necessary.

The illustration on the preceding page shows the apparatus devised by H. A. Gardner to secure photomicrographs of paint films in situ. The small photomicrographs in this book were all taken with this apparatus.

It consists of part of a Gordon photomicrograph tube, such as is used for plate exposures in laboratory work. This tube contains a projection lens properly focused to the back of the tube, and also an

exposure shutter fixed on a lift pin. On the rear end of this tube was placed a disk of metal into which was fitted a block of wood having a central annular opening the size of the tube. On the back of the block was firmly set and screwed into position a film pack, such as is used for the ordinary photographic camera.

The arm and body of an ordinary miscroscope containing a draw tube fitted with objective and eyepiece was mounted in a horizontal position on a solid iron base, the bottom of which was punched and threaded to the standard size to receive the screw from the top of a heavy tripod. This latter piece of apparatus is placed close to the painted surface, and, by raising or lowering the tripod, the microscope can be placed in front of any spot it is desired to inspect. By regulating the coarse adjustment, the microscope is focused on the painted surface in such a way that any checking, cracking, paint coat abrasions, or other disturbing influences, even of the slightest degree, are promptly brought to the eye of the observer. The tube-camera apparatus is then placed directly over the eyepiece of the microscope and exposure is made by lifting the shutter cap for twenty or thirty seconds, according to light conditions, giving an excellent detail photograph.

REPORT ON "1906" TEST FENCE.

Made at inspection November 19-23, 1909, by:

Henry A. Gardner, Director, Scientific Section, Paint Manufacturers' Association.

George Butler, Master Painter.

Charles Macnichol, Master Painter.

TEST NO. 1.

Basic Carbonate White Lead, 100%.

EAST SIDE—	White Pine.	Cedar.
Chalking:	Very bad.	Bad.
Checking:	Extremely deep.	Deep, with cracks.
White Hiding Power:	Good.	Fair.
Color:	Good.	Good.
Condition for Repainting:	Only fair.	Fair.

This paint was also applied on the same woods over ochre priming, and the results in this case were very bad, deeper checking and cracking taking place, and much discoloration.

WEST SIDE—

No detailed report. See general report.

Hard pine on this side of fence very bad, causing scaling of paint. Scaling and cracking result of bad lumber and hailstone abrasions.

TEST NO. 2.

Sublimed White Lead (Basic Sulfate White Lead), 100%.

EAST SIDE—	White Pine.	Cedar.
Chalking:	Bad.	Bad.
Checking:	Very slight.	Of minor order.
White Hiding Power:	Good.	Good.
Color:	Light yellowish tint.	Fair.
Condition for Repainting:	Fair.	Good.

This paint was also applied on the same woods over ochre primer. Results, as in Test No. 1, were uniformly bad, caus-

NOTE.—Gloss is not reported in these tests, as it is not present in any of the formulas.

Condition of Lumber Affecting Paint, West Side 1906 Fence.

ing deep checking and disintegration of the paint coating, and much discoloration.

WEST SIDE—

No detailed report. See general report.

Very bad condition on hard pine. Ochre priming on this side very bad. Scaling and cracking result of hailstone abrasions.

TEST NO. 3.

Formula.

Vehicle—	White.	Gray.
Linseed Oil	90.0%	90.0%
Turpentine and Drier	10.0%	10.0%
	100.0%	100.0%
Pigment—		
Basic Carbonate—White Lead	50.0%	49.6%
Zinc Oxide	50.0%	50.0%
Color		0.4%
	100.0%	100.0%

EAST SIDE—		White Pine.	Cedar.
	Chalking:	Medium.	Medium.
	Checking:	Fine matt—deep in places.	Matt checking—deep in places.
White	Hiding Power:	Good.	Good.
	Color:	Fair.	Good.
	Condition for Repainting:	Fair to good.	Fair to good.

Gray — The gray in this formula was applied to the same kind of woods, and was showing practically the same conditions as the white.

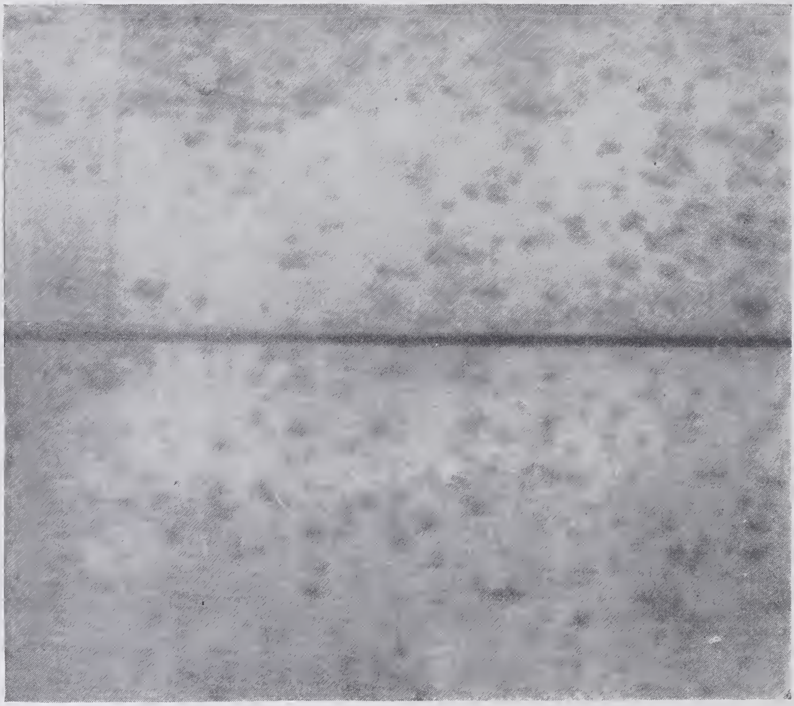
WEST SIDE—

Condition of this paint on the west side was bad, being destroyed in some cases on account of lumber and hailstone abrasions.

TEST NO. 4.

Formula.

Vehicle—	White.
Linseed Oil	90%
Japan Drier	10%
	100%



Hail-StoneEffect on 1906 Fence.

Pigment—

Basic Sulphate—White Lead	60%
Zinc oxide	40%
	100%

EAST SIDE—		White Pine.	Cedar.
	Chalking:	Medium.	Medium.
	Checking:	Surface checking, very slight.	Deeper than on white pine.
White	Hiding Power:	Good.	Good.
	Color:	Good.	Slight yellowish tint.
	Condition for Repainting:	Fair.	Fair to good.

No test on gray.

WEST SIDE—

On west side of fence lumber was bad, destroying the paint coatings in places. No test on grays.

TEST NO. 5.

Formula.

Vehicle—	White.	Gray.
Linseed Oil	93.0%	93.0%
Turpentine Drier	7.0%	7.0%
	100.0%	100.0%
Pigment—		
Basic Carbonate—White Lead	28.7%	28.4%
Zinc Oxide	71.3%	70.7%
Color		0.9%
	100.0%	100.0%

EAST SIDE—		White Pine.	Cedar.
	Chalking:	Slight.	Slight.
	Checking:	Quite deep.	Deep, alligator.
White	Hiding Power:	Medium.	Good.
	Color:	Good.	Medium.
	Condition for Repainting:	Poor. Wrinkles appear in paint coating; formula seems hard.	Fair.

Gray — This formula was also painted out in gray on the same woods. and is showing uniformly better conditions than in the white.

WEST SIDE—

Bad lumber largely responsible for failure here.

TEST NO. 6.

Formu'a.

Vehicle.	White.	Gray.
Linseed Oil	90.7%	90.1%
Turpentine Drier	9.3%	9.9%
	100.0%	100.0%
Pigment—		
Basic Carbonate—White Lead	40.2%	39.3%
Zinc Oxide	50.3%	50.1%
Calcium Carbonate	4.1%	4.2%
Silica and Silicates	5.4%	5.7%
Color		0.7%
	100.0%	100.0%

		White Pine.	Cedar.
EAST SIDE—			
	Chalking:	Medium.	Medium.
	Checking:	Slight surface checking.	Surface checking with lateral cracking of slight order.
White	Hiding Power:	Good.	Good.
	Color:	Good.	Good.
	Condition for Repainting:	Good.	Fair.

Gray — This formula was also painted out on the same woods in gray, and was showing very much the same results as reported on white.

WEST SIDE—Condition fairly good, considering bad lumber, etc .

TEST NO. 7.

Formu'a.

Vehicle.	White.	Gray.
Linseed Oil	89.6%	90.8%
Turpentine and Drier	9.7%	7.3%
Water	0.7%	1.9%
	100.0%	100.0%
Pigment—		
Basic Carbonate—White Lead	21.9%	17.8%
Basic Sulphate—White Lead	21.9%	12.6%
Zinc Oxide	45.8%	40.7%
Calcium Carbonate	10.4%	9.5%
Barium Sulphate		18.3%
Color		1.1%
	100.0%	100.0%

EAST SIDE—		White Pine.	Cedar.
	Chalking:	Medium.	Medium.
	Checking:	Surface checking with slight cracking.	Surface checking. Some peeling.
White	Hiding Power:	Fair.	Fair.
	Color:	Good.	Good.
	Condition for Repainting:	Slight shelling from wood in places.	Fair.

Gray — This formula was also painted out in gray on the same woods, and was showing uniformly better conditions in the gray, with less checking and better surface for repainting.

WEST SIDE—

Lumber conditions, etc., bad. No detailed report.

TEST NO. 8.

Formula.

Vehicle—	White.	Gray.
Linseed oil	86.0%	84.7%
Turpentine Drier	12.6%	13.8%
Water	1.4%	1.5%
	100.0%	100.0%
Pigment—		
Basic Carbonate—White Lead	44.1%	27.3%
Zinc Oxide	46.0%	55.2%
Calcium Carbonate	4.6%	7.1%
Magnesium Silicate	5.3%	6.9%
Color		3.5%
	100.0%	100.0%

EAST SIDE—		White Pine.	Cedar.
	Chalking:	Medium	Medium.
	Checking:	Very slight.	Minor order.
White	Hiding Power:	Good.	Good.
	Color:	Good.	Good.
	Condition for Repainting:	Good.	Good. Showing even better conditions than on pine.

Gray — This formula was also painted out in gray upon the same woods, and is showing very much the same results as in white,

the paint applied to cedar being even somewhat better than that applied to pine.

WEST SIDE—

Lumber conditions, etc., very bad, but paint is showing fair results even under such conditions.

TEST NO. 9.

Formula.

(See Test No. 10 for formula)

EAST SIDE—

Gray — This formula was painted out only in gray. No detailed report made.

Fair condition.

TEST NO. 10.

Formula.

	No. 9 Gray.	No. 10 White.
Vehicle—		
Linseed Oil	68.9%	72.2%
Benzine Drier	16.1%	3.8%
Water	15.0%	24.0%
	100.0%	100.0%
Pigment—		
Basic Carbonate—White Lead	21.7%	13.9%
Zinc Oxide	48.7%	34.9%
Calcium Carbonate	22.0%	26.8%
Clay and Silica	5.4%	
Barytes and Silicate		24.4%
Color	2.2%	
	100.0%	100.0%

EAST SIDE—		White Pine.	Cedar.
	Chalking:	Slight.	Same condition on cedar as on pine, the paint being in very bad condition in every way.
White	Checking:	Very bad.	

This formula is generally destroyed throughout, and is in too bad condition for report.

WEST SIDE—

Shelling clear to wood, and in very bad condition, even on soft pine.

TEST NO. 11.

Formula.

(For formula see Test No. 12.)

This test never finished.

TEST NO. 12.

Formula.

Formula:	No. 11	No. 12.
Basic Carbonate—White Lead	55.0%	
Basic Sulphate—White Lead		5.1%
Zinc Oxide	15.2%	25.0%
Barytes, Silica, etc.	29.8%	69.9%
	100.0%	100.0%

EAST SIDE—		White Pine.	Cedar.
	Chalking:	Medium.	Better conditions on cedar than on pine.
	Checking:	Medium.	
White	Hiding Power:	Deficient.	
	Color:	Good.	
	Condition for Repainting:	Is shelling from wood in places.	

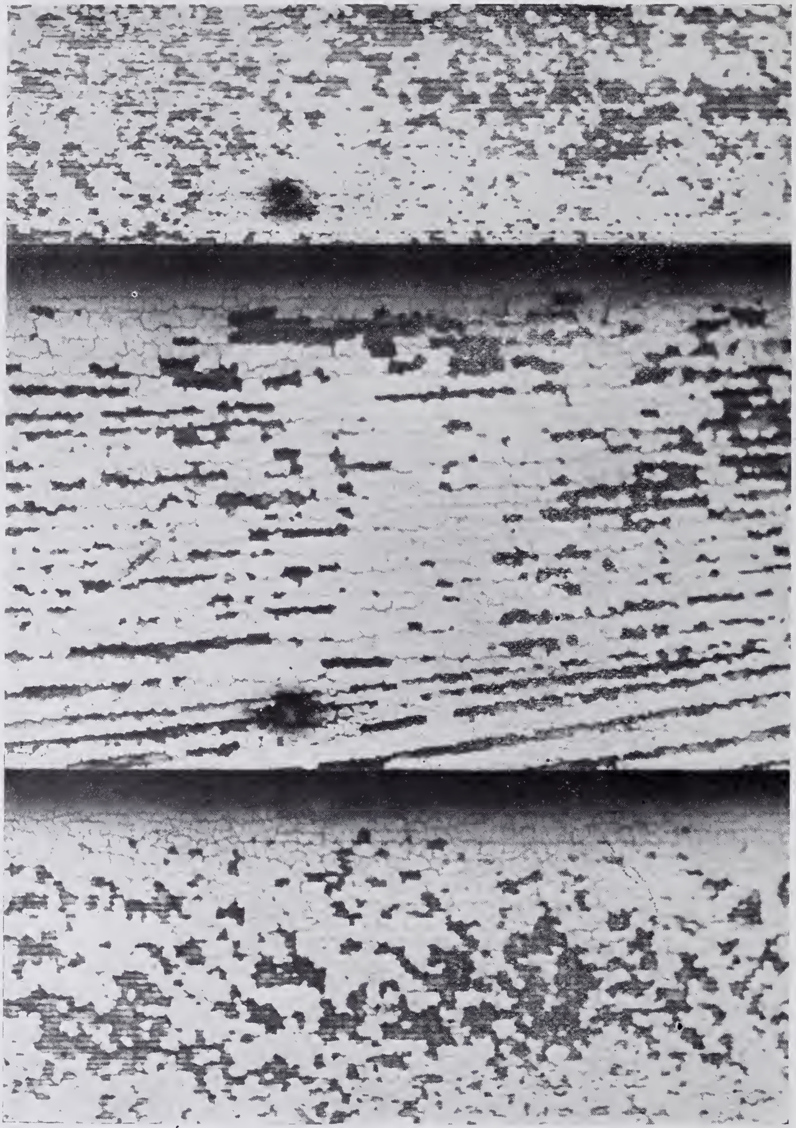
WEST SIDE—

Considerable shelling and cracking on white pine. Bad condition on hard pine largely due to wood.

TEST NO. 13.

Formula.

Formula:	White.	Gray.
Vehicle—		
Linseed Oil	57.2%	54.4%
Benzine Drier	26.7%	28.9%
Water	16.1%	16.7%
	100.0%	100.0%
Pigment—		
Zinc Oxide	31.3%	27.8%
Calcium Carbonate	45.4%	40.1%
Barytes	22.8%	22.1%
Clay, Silica, etc.	0.5%	7.3%
Color		2.7%
	100.0%	100.0%



Test No. 13—1906 Fence
Type of Paint Sold by Mail Order House.
Complete Disintegration and Failure.

This formula totally destroyed throughout in every single test. Early disintegration and destruction is evident. Presents the worst looking surface of any seen in the North Dakota tests.

TEST NO. 14.

Formula.

Formula:	White.	Gray.
Vehicle—		
Linseed Oil	86.0%	84.9%
Turpentine Drier	13.7%	12.8%
Water	0.3%	2.3%
	100.0%	100.0%
Pigment—		
Basic Carbonate—White Lead	34.8%	30.3%
Basic Sulphate—White Lead	5.4%	5.1%
Zinc Oxide	59.2%	64.1%
	99.4%	99.5%

EAST SIDE—		White Pine.	Cedar.
	Chalking:	Medium.	Medium.
	Checking:	Slight surface checking and peeling.	Lateral checking of medium depth. Some alligatoring.
White	Hiding Power:	Fair.	Fair.
	Color:	Good.	Fair.
	Condition for Repainting:	Good.	Good.

Gray — This formula was also painted out in gray on the same woods, and is showing practically the same conditions as in white, except that there is less checking and the surface seems to be in slightly better condition.

WEST SIDE—

Hailstone abrasions deep, and lumber conditions bad.

TEST NO. 15.

Formula.

Formula:	
Vehicle—	
Linseed Oil	98%
Volatile Oil	2%
	100%

Pigment—

Zinc Oxide	64%
Barytes	36%
	100%

EAST SIDE—		White Pine.	Cedar.
	Chalking:	Slight.	Slight.
	Checking:	Lateral cracking quite deep.	Lateral cracking quite deep.
White	Hiding Power:	Good.	Good.
	Color:	Good.	Good.
	Condition for Repainting:	Film seems very hard.	Film seems very hard.

Test incomplete.

TEST NO. 16.

Medium Yellow.

This test showed good maintenance of tone, considerable chalking, and the form of checking characteristic of lead, on the white pine. On the cedar the checking was more moderate and the color maintenance was very good.

TEST NO. 17.

Red Oxide.

This test was in very good condition, with slight chalking and absolute freedom from checking, with good hiding power and good maintenance of tone.

TEST NO. 18.

Maple Green.

This test was in good condition, and, although showing no checking and good maintenance of color, did not have the best covering properties.

TEST NO. 19.

Sky Blue.

Test in fair condition throughout.

REPORT ON "1907" FENCE

Made at inspection, Nov. 19-23, 1909, by:

Henry A. Gardner, Director, Scientific Section, Paint Manufacturers' Association.

George Butler, Master Painter.

Charles Macnichol, Master Painter.

FORMULA NO. 1.

Pigment—	
Basic Carbonate—White Lead	30%
Zinc Oxide	70%
	100%
Vehicle—	
Linseed Oil	93%
Turpentine Drier	7%
	100%

EAST SIDE—		Soft Pine.	Cedar.
	Chalking:	Medium.	Medium.
	Checking:	Considerable with lateral cracking.	Considerable, cracking considerable.
White	Hiding Power:	Fair.	Fair.
Sec. 1	Color:	Fair.	Fair.
	Condition for Repainting:	Poor surface; too hard.	Poor.

Gray Sec. 1 — This formula also applied in gray on the same woods, upon which it showed less cracking and in general better condition, with a good repainting surface.

Yellow Sec. 2 — This paint was also applied in yellow on the same woods, on Section 2, and showed slight chalking with moderate checking, and general good condition, with good maintenance of color.

WEST SIDE—

Wood conditions bad, paint showing considerable cracking, rosin discolorations, etc.

Photographs of West Side of Test Fences.

FORMULA NO. 2.

Pigment—

Basic Carbonate—White Lead	50%
Zinc Oxide	50%
	100%

Vehicle—

Linseed Oil	86%
Turpentine and Japan	10%
Water	4%
	100%

		Soft Pine.	Cedar.
EAST SIDE—			
	Chalking:	Medium.	Medium.
	Checking:	Considerable, with lateral cracking.	Considerable.
White Sec. 3	Hiding Power:	Good.	Good.
	Color:	Fair.	Good.
	Condition for Repainting:	Rather poor.	Rather poor.

Gray Sec. 3 — This formula also applied in gray, in which it showed better conditions than in white, with less checking, and indicating a fair repainting surface.

Yellow Sec. 2 — This formula was applied in yellow on Section No. 2, and showed medium chalking, slight checking with some cracking, with good color and covering properties and fair repainting surface.

WEST SIDE—

Boards on west side bulged and warped. Conditions for repainting bad; wood split. Hailstone abrasions.

FORMULA NO. 3.

Pigment—

Basic Carbonate—White Lead	20%
Basic Sulphate—White Lead	20%
Zinc Oxide	50%
Calcium Carbonate	10%
	100%

Vehicle—

Linseed Oil	90%
Turpentine and Benzine Japan Drier..	10%
	100%

EAST SIDE—		Soft Pine.	Cedar.
	Chalking:	Bad.	Bad.
	Checking:	Medium—scaling some.	Medium.
White	Hiding Power:	Good.	Good.
Sec. 4	Color:	Good.	Good.
	Condition for Repainting:	Fair:	Fair.

Gray Sec. 4 — This formula applied in gray to the same section showed practically the same condition as the white, with the exception that somewhat slighter chalking and checking were shown. The gray on the cedar was better than the gray on the white pine.

Yellow Sec. 5. — This formula was applied in yellow to Section No. 5, and was in very good condition throughout, showing moderate chalking and checking, and general good condition throughout.

WEST SIDE—

Sec. 4 — Conditions of lumber and effect of hailstones cracked this paint very badly indeed, presenting an extremely bad surface, in marked contrast to the good condition on the other side of the fence, on good wood.

FORMULA NO. 4.

Pigment—	
Basic Carbonate—White Lead	48.50%
Zinc Oxide	48.50%
Calcium Carbonate	3.00%
	100.00%

Vehicle—	
Linseed Oil	83%
Drier: 2 pts. Benzine, 1 pt. Turpentine	17%
	100%

EAST SIDE—		Soft Pine.	Cedar.
	Chalking:	Medium.	Bad.
	Checking:	Considerable, with lateral cracking.	Considerable.
White	Hiding Power:	Good.	Good.
Sec. 6	Color:	Good.	Good.
	Condition for Repainting:	Medium.	Much better than on soft pine.

Gray Sec. 6 — This formula applied in gray on the same section showed less chalking than in the white, and with better conditions throughout.

Yellow Sec. 5 — This formula was applied in yellow on Section No. 5, and showed fair conditions thereon. The maintenance of color, however, was not good.

WEST SIDE—

Color faded considerably, but general bad condition of paint thereon was largely due to lumber.

FORMULA NO. 5.

Pigment—	
Basic Carbonate—White Lead	22%
Zinc Oxide	50%
Calcium Carbonate	2%
Aluminum and Magnesium Silicates	26%
	100%

Vehicle—	
Linseed Oil	90%
Drier	10%
	100%

EAST SIDE—		Soft Pine.	Cedar.
	Chalking:	Slight.	Medium.
	Checking:	Slight.	Slight.
White	Hiding Power:	Good.	Good.
Sec. 7	Color:	Good.	Good.
	Condition for Repainting:	Good.	Good.

Gray Sec. 7 — This formula was also applied in gray on the same section and indicated the same general good results as upon white.

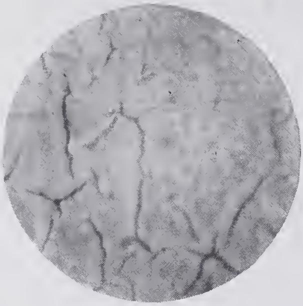
Yellow Sec. 8 — This formula was also applied in yellow on Section No. 8, and showed very good conditions, with good color maintenance.

WEST SIDE—

Considerable splitting was noticed, which was due to condition of wood.

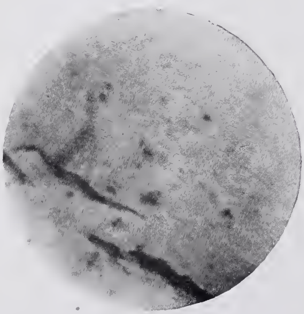
FORMULA NO. 6.

Pigment—	
Zinc Oxide	64%
Barytes	36%
	100%



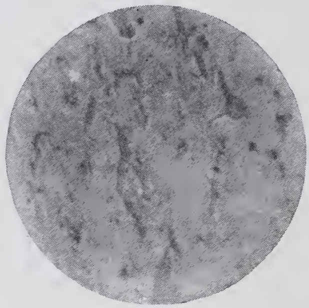
1. Formula No. 21, Section 31, on 1907 Fence.

2. Section 80, on 1908 Fence.

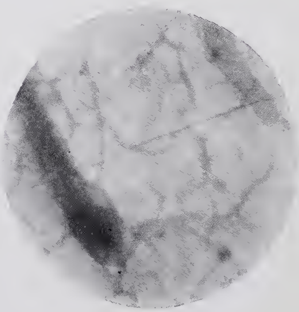


3. Formula No. 6, Section 9, on 1907 Fence.

4. Formula No. 2, Section 3, on 1907 Fence.



5. Formula No. 1, Section 1, on 1907 Fence.



6. Formula No. 14, Section 21, on 1907 Fence.

Vehicle—

Linseed Oil	98%
Volatile Oil	2%
	100%

EAST SIDE—		Soft Pine.	Cedar.
	Chalking:	Medium.	Medium.
	Checking:	Considerable.	Considerable.
White	Hiding Power:	Medium.	Medium.
Sec. 9	Color:	Medium.	Medium.
	Condition for Repainting:	Fair.	Fair.

Gray Sec. 9 — This formula painted out in gray on the same section showed somewhat better conditions.

Yellow Sec. 8 — This formula painted out in yellow on Section No. 8 showed very much the same conditions as indicated by the white, except that less checking and a better surface for repainting was indicated.

WEST SIDE—

This paint on the west side, because of the bad condition of the lumber, was split to a great extent, and in very bad condition on the hard pine wood. Hailstone abrasions on the soft pine caused bad results. The yellow, however, seemed to be in fair condition.

FORMULA NO. 7.

Pigment—

Basic Carbonate—White Lead	37%
Zinc Oxide	63%
	100%

Vehicle—

Linseed Oil	85%
Turpentine Drier	13%
Water	2%
	100%

EAST SIDE—		Soft Pine.	Cedar.
	Chalking:	Considerable.	Considerable.
	Checking:	Present; long cracks evident.	Present; long cracks evident.
White	Hiding Power:	Fair.	Fair.
Sec. 10	Color:	Fair.	Fair.
	Condition for Repainting:	Poor.	Medium.

Gray Sec. 10 — This formula also applied in gray on the same section showed better results, with a very slight cracking, and presenting a fair repainting surface.

Yellow Sec. 11 — This formula also painted out in yellow on Section No. 11, and in this color showed very much the same condition as in the gray, with less cracking than in the white.

WEST SIDE—

Splitting very bad and hailstone effect also bad. The yellow, however, seemed to be in fairly good condition.

FORMULA NO. 8.

Pigment—	
Basic Carbonate—White Lead	38%
Zinc Oxide	48%
Silica	14%
	100%

Vehicle—	
Linseed Oil	91%
Turpentine and Drier	9%
	100%

EAST SIDE—		Soft Pine.	Cedar.
	Chalking:	Slight.	Slight.
	Checking:	Surface checking evident.	Surface checking evident.
White	Hiding Power:	Good.	Good.
Sec. 12	Color:	Good.	Good.
	Condition for Repainting:	Fair.	Good.

Gray Sec. 12 — This formula, painted out on the same section in gray was in very good condition and presented a better repainting surface.

Yellow Sec. 11 — This formula, painted out on Section No. 11 in yellow, and although slight cracking was evident, the formula is in good condition.

WEST SIDE—

This formula split in many places on the hard wood, in white and gray. The yellow, however, was in very good condition.

FORMULA NO. 9.

Pigment—

Zinc Oxide	73%
Silica	25%
Calcium Carbonate	2%
	100%

Vehicle—

Linseed Oil	66%
Drier, 2 pts. Benzine, 1 pt. Turpentine	22%
Water	12%
	100%

EAST SIDE—		Soft Pine.	Cedar.
	Chalking:	Not evident.	Not evident.
	Checking:	Considerable, with lateral cracking.	Lateral cracking.
White	Hiding Power:	Medium.	Good.
Sec. 13	Color:	Good.	Fair.
	Condition for Repainting:	Medium.	Medium.

Gray Sec. 13 — This formula was also applied in gray to the same section but considerable shelling was evident. Otherwise it was in very much the same condition as the white.

Yellow Sec. 14 — This formula was applied on Section No. 14 in yellow, and was showing better hiding power, with good maintenance of color and presenting a general better repainting surface than in the white.

WEST SIDE—

Considerable splitting was noticed on the hard pine.

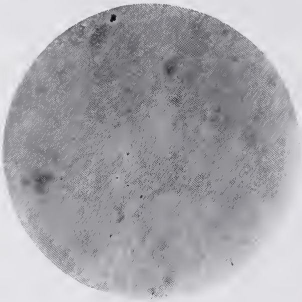
FORMULA NO. 10.

Pigment—

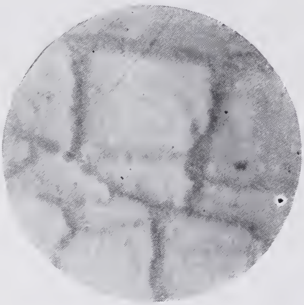
Basic Carbonate—White Lead	44%
Zinc Oxide	46%
Calcium Carbonate	5%
Magnesium Silicate	5%
	100%

Vehicle—

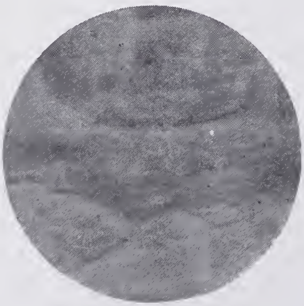
Linseed Oil	86.0%
Turpentine Drier	12.5%
Water	1.5%
	100%



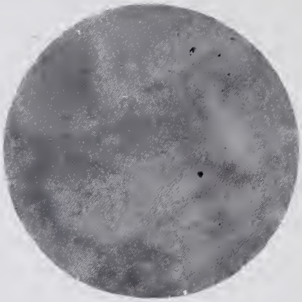
7. Formula No. 13, Panel 19, on 1907 Fence.



8. Formula No. 19, Panel 28. Broad, Deep Checking on Corroded White Lead on 1907 Fence.

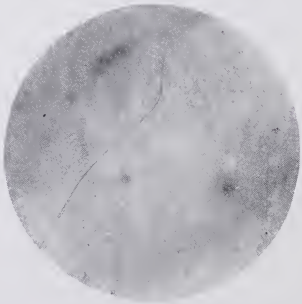


9. Formula No. 24, Panel 36, on 1907 Fence. Good Condition. Surface Checking Only.



10. Formula No. 25, Section 37, on 1907 Fence. Good Condition. Surface Checking Only.

11. Formula No. 8, Panel 12, on 1907 Fence.



12. Formula No. 10, Panel 15, on 1907 Fence.

EAST SIDE—		Soft Pine.	Cedar.
	Chalking:	Medium.	Medium .
	Checking:	Very slight.	Lateral checks of minor order.
White	Hiding Power:	Good.	Good.
Sec. 15	Color:	Good.	Good.
	Condition for Repainting:	Good.	Good.

Gray Sec. 15 — This formula was also applied in gray on the same section, showing even superior condition to the white, and with excellent maintenance of color.

Yellow Sec. 14 — This formula was also applied in yellow on Section No. 14, and the color and condition was excellent thereon.

WEST SIDE—

Considerable splitting and abrasions due to hailstones was noted.

FORMULA NO. 11.

Pigment—

Basic Carbonate—White Lead	50%
Zinc Oxide	50%
	100%

Vehicle—

Linseed Oil	78%
Turpentine Drier	22%
	100%

EAST SIDE—		Soft Pine.	Cedar.
	Chalking:	Slight.	Slight.
	Checking:	Lateral cracking present.	Lateral cracking present. Peeling considerable.
White	Hiding Power:	Fair.	Good.
Sec. 16	Color:	Fair.	Good.
	Condition for Repainting:	Fair.	Fair.

Gray Sec. 16 — Marked improvement over the above conditions was shown in the gray which was painted out on the same section.

Yellow Sec. 17 — This formula was applied in yellow on Section No. 17, and good general conditions were shown in this color.

WEST SIDE—

Considerable splitting was evident, but the yellow was in very good condition.

FORMULA NO. 12.

Pigment—	
Basic Carbonate—White Lead	60%
Zinc Oxide	34%
Inert Material	6%
	100%
Vehicle—	
Linseed Oil	91%
Turpentine Drier	7%
Water	2%
	100%

		Soft Pine.	Cedar.
EAST SIDE—			
	Chalking:	Considerable.	Considerable.
	Checking:	Present, with slight cracking and some scaling.	Fairly deep.
White	Hiding Power:	Fair.	Fair.
Sec. 18	Color:	Fair.	Good.
	Condition for Repainting:	Not very good.	Fair.

Gray Sec. 18 — In the gray, same section, this formula was showing up in far superior condition to the white and presented a good repainting surface.

Yellow Sec. 17 — In the yellow, which was applied to Section No. 17, the paint was in fair condition only.

WEST SIDE—

Considerable splitting and hail abrasions were evident on the west side of the fence.

FORMULA NO. 13.

Pigment—	
Basic Sulphate—White Lead	60%
Zinc Oxide	27%
Magnesium Silicate (Asbestine)	10%
Calcium Carbonate	3%
	100%
Vehicle—	
Linseed Oil	90%
White Drier	10%
	100%

		Soft Pine.	Cedar.
EAST SIDE—			
	Chalking:	Medium.	Medium.
	Checking:	Only surface checking.	Slight.
White	Hiding Power:	Good.	Good.
Sec. 19	Color:	Good.	Good.
	Condition for Repainting:	Good.	Good.

Gray Sec. 19 — This formula applied on the same section in gray was in generally good condition throughout.

Yellow Sec. 20 — Applied in yellow on Section No. 20. Very good results were shown.

WEST SIDE—

Splitting on nearly all woods was shown. The formula, however, indicated good results.

FORMULA NO. 14.

Pigment—	
Basic Carbonate—White Lead	25%
Basic Sulphate—White Lead	20%
Zinc Oxide	25%
Calcium Sulphate	25%
Calcium Carbonate	5%
	100%

Vehicle—	
Linseed Oil	90%
Turpentine Japan Drier	6%
Benzine	4%
	100%

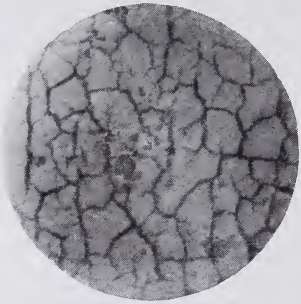
		Soft Pine.	Cedar.
EAST SIDE—			
	Chalking:	Considerable.	Medium.
	Checking:	Considerable, with lateral cracking.	More cracking present
White	Hiding Power:	Medium.	Medium.
Sec. 21	Color:	Fair.	Fair.
	Condition for Repainting:	Only medium; some washing evident.	Medium.

Gray Sec. 21 — The gray applied to the same section was in somewhat better condition than the white.

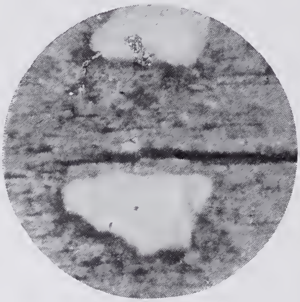
Yellow Sec. 20 — The yellow, applied to Section No. 20, was in much better condition than the white.

WEST SIDE—

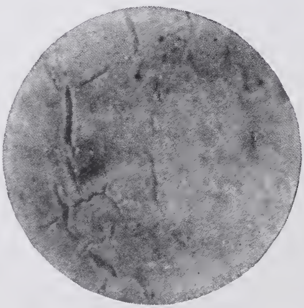
Bad splitting was shown.



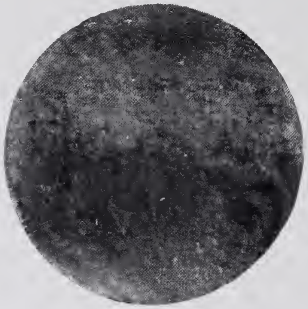
13. Panel No. 34, Formula 23, on 1907 Fence. Deep Checking on Corroded White Lead.



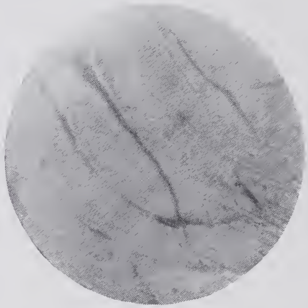
14. Test No. 13 on 1906 Fence. White Spots Show Paint Left on Wood. Balance of Paint Split and Disintegrated from Surface.



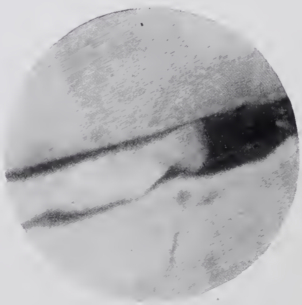
15. Test No. 6 on 1906 Fence. Surface Checking Only.



16. Test No. 2, 1906 Fence. Sublimed White Lead.



17. Cracks in Test No. 15 on 1906 Fence.



18. Effect of Cracking on Hard Pine, Causing Splitting of Paint Coating.

FORMULA NO. 15.

Pigment—	
Standard Zinc Lead	30%
Zinc Oxide	40%
Basic Sulphate—White Lead	20%
Calcium Carbonate	10%
	100%
Vehicle—	
Linseed Oil	90%
Turpentine Japan Drier	8%
Water	2%
	100%

EAST SIDE—		Soft Pine.	Cedar.
	Chalking:	Medium.	Medium.
	Checking:	Medium.	Slight.
White	Hiding Power:	Good.	Good.
Sec. 22	Color:	Good.	Fair.
	Condition for Repainting:	Medium.	Medium.

Considerable hailstone abrasions were noticed on this section.

Gray Sec. 22 — In the gray on the same panel, this formula presented a much better repainting surface.

Yellow Sec. 23 — This formula, painted in yellow on Section No. 23, was in excellent condition, with good color maintenance.

WEST SIDE—

This formula was in very bad condition, especially in the yellow. Bad condition of lumber.

FORMULA NO. 16.

Pigment—	
Basic Carbonate—White Lead	33%
Zinc Oxide	33%
Barytes (Floated)	34%
	100%
Vehicle—	
Linseed Oil	90%
Turpentine Japan Drier	10%
	100%

		Soft Pine.	Cedar.
EAST SIDE—			
	Chalking:	Medium.	Medium.
	Checking:	Slight, with some shelling.	Split.
White	Hiding Power:	Fair.	Fair.
Sec. 24	Color:	Good.	Good.
	Condition for Repainting:	Medium.	Medium.

Gray Sec. 24 — This formula, applied on the same section in gray, was in fair condition.

Yellow Sec. 23 — This formula, applied in yellow on Section No. 23, was in good condition.

WEST SIDE—

Bad conditions were shown, probably due to the lumber. The yellow, however, had faded.

FORMULA NO. 17.

Corroded White Lead, Type A.

		Soft Pine.	Cedar.
EAST SIDE—			
	Chalking:	Bad.	Bad.
	Checking:	Alligatoring and checking very deep.	Alligatoring and checking very deep.
White	Hiding Power:	Good.	Good.
Sec. 25	Color:	Fair.	Fair.
	Condition for Repainting:	Poor.	Poor.

Gray Sec. 25 — This formula on the same section in gray showed in superior condition to the white.

Yellow Sec. 26 — This formula, applied in yellow on Section No. 26, had a poor appearance, with bad color, looking as though it had been applied with ochre.

WEST SIDE—

Bad condition of wood caused failure of the formula.

FORMULA NO. 18.

Corroded White Lead, Type B.

		Soft Pine.	Cedar.
EAST SIDE—			
	Chalking:	Bad.	Bad.
	Checking:	Alligatoring and checking deep.	Alligatoring and checking deep.
White	Hiding Power:	Fair.	Good.
Sec. 27	Color:	Fair.	Fair.
	Condition for Repainting:	Poor.	Poor.

Gray Sec. 27	This formula, applied in gray on the same section, was in much superior condition to the white.
Yellow Sec. 26	This formula, applied in yellow on Section No. 26, was in fair condition, with the exception that considerable fading was shown.

WEST SIDE—

Bad condition of wood caused failure of the formula.

FORMULA NO. 19*

Corroded White Lead, Type C.

EAST SIDE—

		Soft Pine.	Cedar.
	Chalking:	Bad.	Bad.
	Checking:	Deep.	Deep.
White	Hiding Power:	Good.	Good.
Sec. 28	Color	Fair.	Fair.
	Condition for Repainting:	Poor.	Poor.

Gray Sec. 28	In the gray, on the same section, this formula was in better condition.
Yellow Sec. 29	This formula was applied in yellow on Section No. 29, and, although evidencing considerable checking, was in fair condition, with the exception of the color which was somewhat darkened.

WEST SIDE—

Condition of paint due to unfair condition of lumber. Cracking, etc.

FORMULA NO. 20.

Sublimed White Lead.

EAST SIDE—

		Soft Pine.	Cedar.
	Chalking:	Considerable.	Bad.
	Checking:	Slight.	Slight.
White	Hiding Power:	Good.	Medium.
Sec. 30	Color:	Fair.	Fair.
	Condition for Repainting:	Fair.	Fair.

Gray Sec. 30	On the same section, this formula was applied in gray, and was showing up in better condition than in the white.
Yellow Sec. 29	This formula was applied in yellow on Section No. 29, and showed a better maintenance of color than the corroded white lead.

WEST SIDE—

This formula showed poor hiding power.

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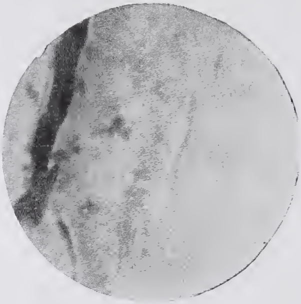
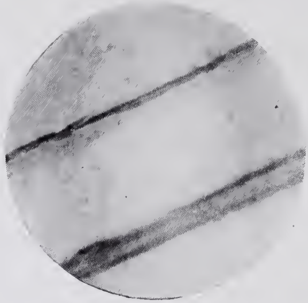
* Applied with 10-gal. oil reduction. See Formula No. 23, Section No. 34.

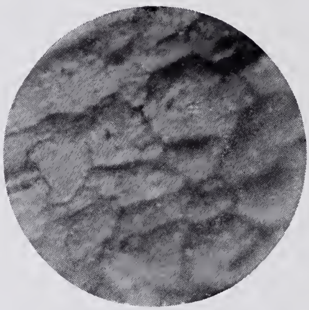


19. Formula No. 22, Section 23, 1907 Fence. Cracks in Paint Coating, Caused by Cracks in Wood; Coating Otherwise in Good Condition.

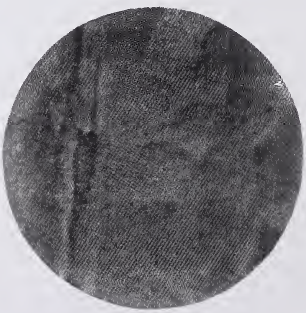


22. Cracks in Paint Coating, Caused by Cracking of Hard Pine Wood.

20. Test No. 8, on 1906 Fence. Surface Checking Only.



23. Section 65 on 1908 Fence. Showing Early Breakdown of Corroded White Lead.



21. Combination Cracking and Checking on Section 69, on 1908 Fence.

FORMULA NO. 21.

Zinc Oxide.

EAST SIDE—		Soft Pine.	Cedar.
	Chalking:	Not evident.	Not evident.
	Checking:	Considerable, with slight cracking and some scaling.	Less cracking.
White	Hiding Power:	Fair.	Fair.
Sec. 31	Color:	Good.	Good.
	Condition for Repainting:	Poor.	Better.

Gray Sec. 31 — This formula, painted in gray on the same section, was showing uniformly better conditions, with less checking.

Yellow Sec. 32 — This formula was painted in yellow on Section No. 32, and was in fair condition, except for some cracking.

WEST SIDE—

Considerable splitting was shown on the white and gray. The yellow was in very good condition, however.

FORMULA NO. 22.

Zinc-Lead White.

EAST SIDE—		Soft Pine.	Cedar.
	Chalking:	Medium.	Medium.
	Checking:	Lateral cracking with splits.	Considerable.
White	Hiding Power:	Good.	Good.
Sec. 33	Color:	Good.	Good.
	Condition for Repainting:	Fair.	Fair.

Gray Sec. 33 — The gray on this section showed better conditions than the white.

Yellow Sec. 32 — The yellow, applied to Section No. 32, was in good condition.

WEST SIDE—

The condition of the wood and hail abrasions were bad

FORMULA NO. 23*.

Corroded White Lead, Type C.

		Soft Pine.	Cedar.
EAST SIDE—			
	Chalking:	Bad.	Bad.
	Checking:	Medium deep.	Medium deep.
White	Hiding Power:	Good.	Poor, grain showing through.
Sec. 34	Color:	Good.	Good.
	Condition for Repainting:	Fair.	Fair.

Gray Sec. 34 — This formula in gray was in better condition than in the white.

Yellow Sec. 35 — Applied in yellow to Section No. 35, this formula was in fair condition except for checking.

WEST SIDE—

Wood was poor and showed rosin exudations.

FORMULA NO. 24.

Michigan Seal White Lead.

Formula:

Basic Carbonate—White Lead	37.51%
Basic Sulphate—White Lead	7.84%
Zinc Oxide	25.87%
Calcium Carbonate	20.36%
Barytes, Silica & Undetermined....	8.42%
	100.00%

		Soft Pine.	Cedar.
EAST SIDE—			
	Chalking:	Considerable.	Considerable.
	Checking:	Slight; some lateral cracking shown.	Slight.
White	Hiding Power:	Fair.	Poor.
Sec. 36	Color:	Good.	Good.
	Condition for Repainting:	Good.	Good.

Gray Sec. 36 — This formula in gray, applied to the same section, was in generally good condition.

Yellow Sec. 35 — This formula in yellow, applied to Section No. 35, showed a very superior color maintenance.

WEST SIDE—

Considerable knots shown in wood, with cracking, splitting and exudation of rosin.

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* Applied with 5½-gallon oil reduction on priming coat.

FORMULA NO. 25.

Railway White Lead.

Formula:

Basic Carbonate—White Lead	38.95%
Basic Sulphate—White Lead	4.81%
Zinc Oxide	33.58%
Calcium Carbonate	19.48%
Barytes and Silica	3.18%
	100.00%

EAST SIDE—		Soft Pine.	Cedar.
	Chalking:	Considerable.	Considerable.
	Checking:	Some, with lateral cracks.	Cracking considerable
White	Hiding Power:	Fair.	Fair.
Sec. 37	Color:	Good.	Good.
	Condition for Repainting:	Excellent.	Fair.

Gray Sec. 37 — This formula in gray, applied to the same section, was standing up well.

Yellow Sec. 38 — This formula in yellow, applied to Section No. 38, showed very fair conditions except for slight fading.

FORMULA NO. 200.

Basic Carbonate—White Lead ...	15.625%
Zinc Lead	43.750%
Magnesium Silicate	1.250%
Calcium Carbonate	1.875%
Linseed Oil	32.250%
Turpentine Drier	4.000%
Water	1.250%
	100.000%

EAST SIDE—		Soft Pine.
	Chalking:	Medium.
	Checking:	Cracking bad.
White	Hiding Power:	Good.
Sec. 39	Color:	Good.
	Condition for Repainting:	Fair.

FORMULA NO. 201.

Basic Carbonate—White Lead	11.66%
Zinc Lead	43.83%
Magnesium Silicate	1.15%
Calcium Carbonate	1.74%
Tinting Color	6.59%
Linseed Oil	30.10%
Turpentine Drier	3.77%
Water	1.16%
	100.00%

Gray Sec. 39 Applied to Section No. 39 in gray. Very good condition throughout. The wood, however, was broken in several places.

FORMULA NO. 202.

Basic Carbonate—White Lead ...	12.39%
Zinc Lead	46.35%
Magnesium Silicate	1.27%
Calcium Carbonate	1.89%
Tinting Color	0.94%
Linseed Oil	31.83%
Turpentine Drier	4.09%
Water	1.24%
	100.00%

EAST SIDE—

Yellow Sec. 38 Formula No. 202, applied in yellow on Section No. 38, is showing up well.

SPECIAL TEST. PANEL NO. 40.

This test was made with a formula containing:

50% Eagle White Lead.
50% N. J. Zinc Oxide XX.

This formula was tried out in two-coat work throughout.

On Section No. 1, Panel No. 40, white pine, it was reduced with bleached oil. Darkening was shown.

On Section No. 2 it was reduced with ½ rosin oil and ½ raw linseed oil. Very poor covering and bad checking was shown, but the formula was very white.

On Section No. 3 it was reduced with ½ cottonseed oil and ½ linseed oil. Bad splitting and darkening was shown.

On Section No. 4 it was reduced with regular raw oil, flowed on very thick. Condition was medium.

REPORT ON SPECIAL TESTS.

Made at inspection, Nov. 19-23, 1909, by:

Henry A. Gardner, Director, Scientific Section, Paint Manufacturers 'Association.

George Butler, Master Painter.

Charles Macnichol, Master Painter.

In the special paint tests begun in 1907 on portable frames and placed on the special fence No. 4, a series of formulas was painted out, starting with 100% lead and adding thereto varying amounts of zinc until a formula containing 100% zinc oxide was reached.

Section 42, Panel F, painted with 80% White Lead and 20% Zinc Oxide XX, was showing the best results, presenting better repainting condition and better general conditions than the other mixtures of lead and zinc.

1908 TEST FENCE.

Inasmuch as these paint tests have been out but a year, no detailed report was made; just general conclusions from an inspection that was not thorough being indicated, and these were made almost entirely from the eastern exposure, the western exposure presenting much the same conditions as shown on the other fences.

SECTION 65.

Formula: 100% Corroded White Lead.

Top Panel (in white). Very bad checking shown.

Second Panel. 75% Lead.
25% Zinc Oxide.

Much better condition shown than on above panel.

SECTION 66.

Top Panel. 100% Corroded White Lead, over ochre, in white. Very bad condition shown.

Same formula in yellow was showing up well.

Second Panel. 75% White Lead.
25% Zinc Oxide. } Over ochre.

Effect of ochre bad.

Same formula in gray was showing up well.

SECTION 67.

Formula: 100% Corroded White Lead.
Top Panel. Yellow.
Second Panel. Gray.
General conditions very good.

SECTION 68.

Top Panel. First and second coats: Pure White Lead.
Third coat: 75% White Lead.
25% Zinc Oxide.
Fairly good conditions were shown throughout.
Second Panel. Same formula applied in white, with a reduction of 2-3 raw oil and 1-3 turpentine.

Formula on this panel is whiter than the above, but is chalking more.

SECTION 69.

Top Panel. 100% White Lead over orange shellac primer.
Checking very bad. Same formula in yellow bad.
Second panel. 75% White Lead. } Over orange shellac primer.
25% Zinc Oxide. }

This formula both in white and gray is showing bad on account of shellac primer.

SECTION 70.

Top panel. 85% White Lead.
15% Zinc Oxide.
Condition good.
Second panel. 80% White Lead.
20% Zinc Oxide.
Considerable chalking; rosin showing through.

SECTION 71.

Painted with Corroded White Lead.
Excessive chalking and peculiarly large checks shown.

SECTION 72.

Formula:

White Lead 70%
Zinc Oxide 30%

Top Panel. Chalking bad. Other conditions fairly good.
Second panel:

White Lead 50%
Zinc Oxide 50%

Condition fair throughout.

SECTION 73.

Top panel. Outside White:

White Lead	45%
Zinc Oxide	45%
Calcium Carbonate	5%
Asbestine	5%
	100%

In good condition.

Second panel. Painted in gray. Formula:

Leaded Zinc Oxide	57%
White Lead	28%
Calcium Carbonate	7%
Asbestine	7%

Condition good.

SECTION 74.

Outside White.

Top panel. White.

Second panel. Gray.

Good condition.

SECTION 75.

Top panel. Outside White:

White Lead	45%
Calcium Carbonate	10%
Zinc Oxide	45%

Good condition.

Second panel. Gray:

Carbonate of Lead	20%
Sulphate of Lead	20%
Zinc Oxide	46%
Barytes	10%
Calcium Carbonate	5%

Good condition.

SECTION 76.

Formula in White and Gray:

Carbonate of Lead	23%
Zinc Oxide	31%
Silica	8%
Oil	34%
Turpentine	4%
	100%

Generally good condition.

SECTION 77.

Outside White.

Sublimed Lead	40%	in white and gray.
Zinc Oxide	60%	

Panel in generally good condition.

SECTION 78.

Imported English Carbonate of Lead, in White and Gray.
In fairly good condition.

SECTION 79.

Sublimed White Lead ...	60%
Zinc Oxide	40%

Top panel in white.
Generally good condition.
Second panel. Light Fawn:

Zinc Oxide	62%
Calcium Carbonate	37%
	99%
Vehicle—	
Linseed Oil	72%
Water	18%
Benzine	10%
	100%

Generally good condition for one year exposure.

SECTION 80.

Mild Process White Lead. In white, gray and yellow.
Good condition throughout.

SECTION 81.

Imported English White Lead, in white, gray and yellow.
Generally good condition throughout.

On the west side of this fence, panels 66, 67, 69, 70, 71, 72, 73, 74, 77, 78 and 80 showed bad rosin exudations.

CATALOGUE

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Petroleum and Its Products—2 Vols. —*Sir Boverton Redwood*

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Handbook on Petroleum —*Thomson Redwood*

A Treatise on the Industrial Use of its Products.

Simple Methods for Testing Painters' Materials —*A. C. Wright*

Letters to a Painter —*Ostwald-Morse*

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Manual of Quantitative Chemical Analysis —*E. F. Ladd*
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An Outline of the Theory of Solution and Its Results —*J. L. R. Morgan*
Notes on the Structure of Paint Films —*L. S. Hughes*
The Lead and Zinc Pigments —*C. D. Holley*

Transactions of the American Electrochemical Society, 1909.

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Bulletins of the Census Bureau.

Paints for Steel Structures —*Houston Lowe*
The Chemistry of Photography —*Raphael Meldola*

Pamphlets

- The Corrosion of Iron —*A. S. Cushman*
- Corrosion of Fence Wire —*A. S. Cushman*
- Some Technical Methods of Testing Miscellaneous Supplies —*P. H. Walker*
- The Analysis of Turpentine by Fractional Distillation with Steam —*Wm. C. Geer*

Periodicals:

- Journal of Industrial and Engineering Chemistry
- Journal of the American Chemical Society
- Chemical Abstracts
- Oil, Paint and Drug Reporter
- The Decorator
- Drugs, Oils and Paints
- The Painters' Magazine
- The American Paint and Oil Dealer
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Publications of the Scientific Section

BUREAU OF PROMOTION AND DEVELOPMENT

PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

Bulletin
Number

Preliminary Booklet—Addresses on Paint, Delivered Before the Michigan Chapter, American Institute of Architects, 1907. (*Out of print.*)

1—Tables of White Pigments and Vehicle—Standard Nomenclature.

2—Standard Can Sizes Recommended to Paint Manufacturers.

3—First Report on the Test Fences Erected by the Scientific Section. (*Out of print.*)

4—Methods for the Analysis of the Vehicle Constituents of Paint. (Out of print.)

5—Tests Upon the Corrosion of Iron to be Conducted by the Scientific Section. (*Out of print.*)

6—First Annual Report of the Scientific Section.

7—Preliminary Report on Steel Test Fences.

8—Report of Committee "E" on Preservative Coatings for Iron and Steel. (*Out of print.*)

9—Recent Technical Developments in Paint Manufacture.

10—Protective Coatings for Conservation of Structural Material.

11—The Corrosion of Iron and Steel. *By Alfred Sang.* (*Out of print.*)

Bulletin
Number

12—The Function of Oxygen in the Corrosion of Metals. *By William H. Walker.*

13—Protective Coatings for Steel and Iron. *By Robert S. Perry.* (*Out of print.*)

14—Coatings for the Conservation of Structural Material. (*Out of print.*)

15—Protective Coatings for Structural Material. *By R. S. Perry.*

16—First Annual Report on Wearing of Paints Applied to Atlantic City Test Fence.

17—First Annual Report on Wearing of Paints Applied to Pittsburg Test Fence.

18—First Annual Report on Atlantic City Steel Test Fence.

19—Laboratory Study of Panels on Atlantic City and Pittsburg Test Fences.

20—Concrete Coatings. *By H. A. Gardner.*

21—A Brief Talk on Paints. *By Henry A. Gardner.*

22—Annual Report for 1909.

Preliminary Bulletin—Second Edition—Physical Characteristics of a Paint Coating. *By R. S. Perry.*

23—The Theory of Driers, Etc.

24—Some Iron Oxides and Their Values.

25—Report on Examination of North Dakota Test Fences.

Some of Inspection Party at Fence Behind Snowdrift

Bulletin No. 26

Second Annual Report

on Wearing of Paints Applied to Atlantic City Test Fence

ATLANTIC CITY TEST FENCE

SCIENTIFIC SECTION—EDUCATIONAL BUREAU

HENRY A. GARDNER, Director

PAINT MANUFACTURERS' ASSOCIATION
OF THE UNITED STATES

PHILADELPHIA, PA.

SECOND ANNUAL REPORT

on

Wearing of Paints Applied

to

Atlantic City Test Fence

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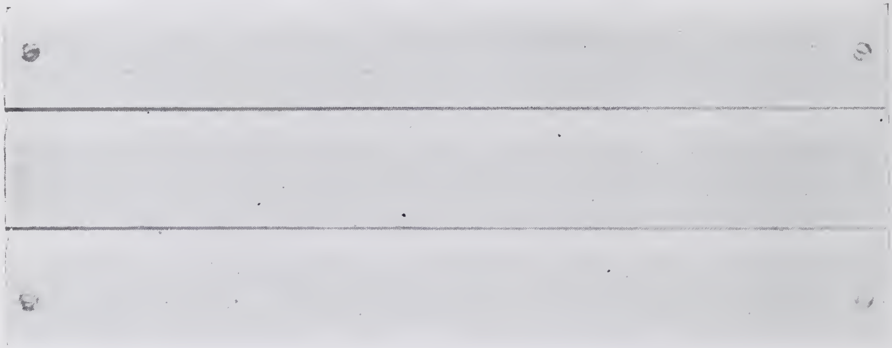
Philadelphia, Pa.

PREFACE

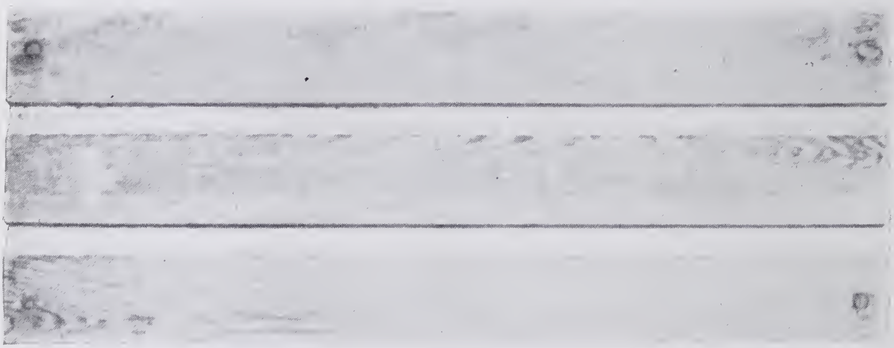
THIS report, made by the joint committees represented in the test, sums up in a final manner the results obtained to date. The ability of the master painter and architect to avail themselves of the facts garnered from these tests and to apply them in their specifications has been fairly commensurate with the great strides of progress and improvement which these tests have effected in the painting industry.

HENRY A. GARDNER,
Director.

Combination Pigment Paint



Single Pigment Paint



Cuts Showing Good Condition of Combination Type of Paint vs. Single Pigment Type

General Report

The second annual inspection of the paints applied to the Atlantic City test fence was made on May 10th, 1910, by a committee representing the Master Painters' Association of Philadelphia and the Scientific Section of the Paint Manufacturers' Association of the United States.

The painted panels were all carefully inspected by the inspectors in the usual manner. With the aid of high-power magnifying glasses, checking was determined. The degree of chalking exhibited by the various paints was ascertained by rubbing a piece of black cloth across the surface of each paint. Close observance was made to determine scaling, peeling, cracking, gloss, color and the other factors to be considered when examining a painted surface. From these observations it was possible for the inspectors to state whether a panel exhibited general good condition, general fair condition or general poor condition.

An inspection of the white lead paints on the fence indicated in every instance a rough, chalked and disintegrated surface that seemed to be well worn, in some cases nearly to the wood. The strongly oxidizing air of the seacoast is probably responsible for the early decay of this pigment.

It was observed that the combination type of paint showed better hiding power than white lead, over the black crosses placed on the priming coat of each panel, as a hiding power test.

There are no pigments possessing greater hiding properties when first used, then white leads, but the lack of hiding power on the white lead panels after two years' exposure was caused by the chalking away of the lead. The superior hiding power of the composite paints was due to the action of the other pigments in these combination paints in preventing the lead from chalking away.

The Committee finds that the addition of a reasonable percentage of zinc oxide to white lead increases its durability and retards its chalking, renders it whiter, and forms a surface that presents a much better repainting condition. The combinations of white lead and zinc oxide on the Atlantic City test fence were in general good condition throughout.

Corroded white lead, sublimed white lead, zinc oxide, and zinc lead are the standard white opaque pigments. They were all tested on the Atlantic City fence and it was found that to use any one alone results in inferior protection to the wood. Barium sulphate, silica, asbestine, china clay, and calcium carbonate are the standard crystalline pigments. In the past, the overloading of paints with these crystalline or inert pigments has been the cause of the prejudice that painters have had against their use. It has been established beyond controversy, however, that the use of these pigments, in moderate percentage, combined with any of the standard opaque white pigments, such as white leads, zinc oxide, etc., undoubtedly results in better service from every standpoint and forms the most satisfactory white paint for general outside use. Some of the most perfect painted surfaces on the fence were those made on the above basis as reference to the charted report will show.

Signed

Geo. Butler

Official Painter Atlantic City Test Fence, Representing Philadelphia Master Painters' Association.

Chas. Macnichol

Master Painter

Henry A. Gardner

Director Scientific Section

TESTS INAUGURATED IN 1907

CHART OF RESULTS OF INSPECTION OF ATLANTIC CITY TEST FENCE, MAY, 1910

FORMULAS											REPORT OF INSPECTION				
					INERT PIGMENTS										
Formula Number	Basic Carbonate White Lead	Zinc Oxide	Basic Sulphate White Lead	Zinc Lead White	Calcium Carbonate	Calcium Sulphate	Magnesium Silicate	Barium Sulphate	Silica	Blanc Fixe	CHALKING	CHECKING	GENERAL CONDITION	REMARKS	Panel Number
	%				%	%	%	%	%	%					
1	30	70									Very slight	Very slight	Good		1
2	50	50									Medium	Slight	Very good		3
3	20	50	20		10						Medium	Slight	Good		5
4	48.5	48.5			3.0						Very slight	Slight	Good		7
5	22	50			2		26				Slight	Slight	Good		9
6		64						36			Very slight	Slight	Good		11
7	37	63									Medium	Slight	Good		13
8	38	48							14		Slight	Very slight	Good		15
9		73			2				25		Very bad	Deep, with scaling	Poor		17
10	44	46			5		5				Heavy	Deep	Medium		19
11	50	50									Medium	Medium	Fair		21
12	60	34				6% Inert Pigment					Medium	Deep	Fair		23
13		27	60		3		10				Medium	Slight	Very good		25
14	25	25	20		5	25					Medium	Lateral	Fair		27
15	20	40		30	10						Slight	Visible with naked eye	Poor		29
16	33	33						34			Slight	Slight	Good		31
17	40	40					3	13		4	Medium	Slight	Good		33
18	75	25									Medium	Slight	Very good		145
19		25	75								Considerable	Deep	Good		147
20	67.0	19.5			10.0		3.5				Medium	Slight	Good		149
33	15	30	25						30		Medium	Slight	Very good		176
34	38.95	33.58	4.81		19.48			1.59	1.59		Slight	Slight lateral	Good		175
35	37.51	25.87	7.84		20.36			4.21	4.21		Slight	Lateral	Good		180
36	100										Considerable	Heavy	Fair	Rough surface	181
37	100										Considerable	Heavy and deep	Poor	Rough surface	182
38	100										More than Panel No. 182	Very deep	Poor		177
39				100							Considerable	Very slight	Good		178
40			100								Heavy	Slight	Good		168
45		90			10						Slight	Slight	Good		170
46		61						39			Slight	Medium	Fair		169
47		100									None	Very deep	Poor		172

Inspection of 1907 Test Panels on Atlantic City Wooden Test Fence

Formula No. 1—Panel No. 1.

Basic Carbonate — White Lead	30%	Chalking: Very Slight.
Zinc Oxide	70%	Checking: Very Slight.
	100%	General Condition: Good.

Formula No. 2—Panel No. 3.

Basic Carbonate — White Lead	50%	Chalking: Medium.
Zinc Oxide	50%	Checking: Slight.
	100%	General Condition: Very good.

Formula No. 3—Panel No. 5.

Basic Carbonate — White Lead	20%	Chalking: Medium.
Basic Sulphate—White Lead	20%	Checking: Slight.
Zinc Oxide	50%	General Condition: Good.
Calcium Carbonate	10%	
	100%	

Formula No. 4—Panel No. 7.

Basic Carbonate — White Lead	48.5%	Chalking: Very Slight.
Zinc Oxide	48.5%	Checking: Slight.
Calcium Carbonate	3.0%	General Condition: Good.
	100.0%	

Note.—Whiteness is not reported on except in special cases as nearly all the panels at Atlantic City on the old tests presented white surfaces.

Formula No. 5—Panel No. 9.

Basic Carbonate — White Lead 22%	Chalking: Slight.
Zinc Oxide 50%	Checking: Slight.
Calcium Carbonate 2%	General Condition: Good.
Aluminum Silicate and Asbestine 26%	
100%	

Formula No. 6—Panel No. 11.

Zinc Oxide 64%	Chalking: Very Slight.
Barytes 36%	Checking: Slight.
100%	General Condition: Good.

Formula No. 7—Panel No. 13.

Basic Carbonate — White Lead 37%	Chalking: Medium.
Zinc Oxide 63%	Checking: Slight.
100%	General Condition: Good.

Formula No. 8—Panel No. 15.

Basic Carbonate — White Lead 38%	Chalking: Slight.
Zinc Oxide 48%	Checking: Very Slight.
Silica 14%	General Condition: Good.
100%	

Formula No. 9—Panel No. 17.

Zinc Oxide 73%	Chalking: Very bad.
Silica 25%	Checking: Deep with scaling.
Calcium Carbonate 2%	General Condition: Poor.
100%	

Formula No. 10—Panel No. 19.

Basic Carbonate — White Lead	44%	Chalking: Heavy.
Zinc Oxide	46%	Checking: Deep.
Calcium Carbonate	5%	General Condition: Medium.
Asbestine	5%	
	100%	

Formula No. 11—Panel No. 21.

Basic Carbonate — White Lead	50%	Chalking: Medium.
Zinc Oxide	50%	Checking: Medium.
	100%	General Condition: Fair.

Formula No. 12—Panel No. 23.

Basic Carbonate — White Lead	60%	Chalking: Medium.
Zinc Oxide	34%	Checking: Deep.
Inert Pigment	6%	General Condition: Fair.
	100%	

Formula No. 13—Panel No. 25.

Basic Sulphate—White Lead	60%	Chalking: Medium.
Zinc Oxide	27%	Checking: Slight.
Asbestine	10%	General Condition: Very good.
Calcium Carbonate	3%	
	100%	

Formula No. 14—Panel No. 27.

Basic Carbonate — White Lead	25%	Chalking: Medium.
Basic Sulphate—White Lead	20%	Checking: Lateral.
Zinc Oxide	25%	General Condition: Fair.
Calcium Sulphate	25%	
Calcium Carbonate	5%	
	100%	

Formula No. 15—Panel No. 29.

Zinc Lead White	30%	Chalking: Slight.
Zinc Oxide	40%	Checking: Visible with naked eye.
Basic Carbonate — White Lead	20%	General Condition: Poor.
Calcium Carbonate	10%	
	100%	

Formula No. 16—Panel No. 31.

Basic Carbonate — White Lead	33%	Chalking: Slight.
Zinc Oxide	33%	Checking: Slight.
Barytes	34%	General Condition: Good.
	100%	

Formula No. 17—Panel No. 33.

Barytes	13%	Chalking: Medium.
Blanc Fixe	4%	Checking: Slight.
Asbestine	3%	General Condition: Good.
Zinc Oxide	40%	
Basic Carbonate — White Lead	40%	
	100%	

Formula No. 18—Panel No. 145.

Basic Carbonate — White Lead (in oil)	75%	Chalking: Medium.
Zinc oxide (in oil)	25%	Checking: Slight.
	100%	General Condition: Very good.

Formula No. 19—Panel No. 147.

Basic Sulphate — White Lead (in oil)	75%	Chalking: Considerable.
Zinc Oxide (in oil)	25%	Checking: Deep.
	100%	General Condition: Good.

Formula No. 20—Panel No. 149.

Basic Carbonate — White Lead	67.0%	Chalking: Medium.
Zinc Oxide	19.5%	Checking: Slight.
Asbestine	3.5%	General Condition: Good.
Calcium Carbonate	10.0%	
	100.0%	

Formula No. 33—Panel No. 176.

Zinc Oxide	30%	Chalking: Medium.
Special Silica	30%	Checking: Slight.
Basic Carbonate — White Lead	15%	General Condition: Very good.
Basic Sulphate—White Lead	25%	
	100%	

Formula No. 34—Panel No. 175.

Basic Carbonate — White Lead	38.95%	Chalking: Slight.
Lead Sulphate	4.81%	Checking: Slight Lateral.
Zinc Oxide	33.58%	General Condition: Good.
Calcium Carbonate	19.48%	
Barytes and Silica	3.18%	
	100.00%	

Formula No. 35—Panel No. 180.

Basic Carbonate — White Lead	37.51%	Chalking: Slight.
Lead Sulphate	7.84%	Checking: Lateral.
Zinc Oxide	25.87%	General Condition: Good.
Calcium Carbonate	20.36%	
Barytes and Silica	8.42%	
	100.00%	

Formula No. 36—Panel No. 181.

Basic Carbonate — White Lead ....100% Type B.	Chalking: Considerable. Checking: Heavy. General Condition: Fair Remarks: Rough surface.

Formula No. 37—Panel No. 182.

Basic Carbonate — White Lead ....100% Type C.	Chalking: Considerable. Checking: Heavy and deep. General Condition: Poor. Remarks: Rough surface.

Formula No. 38—Panel No. 177.

Basic Carbonate — White Lead ....100% Type A.	Chalking: More than panel No. 182. Checking: Very deep. General Condition: Poor.

Formula No. 39—Panel No. 178.

Zinc Lead 100%	Chalking: Considerable. Checking: Very slight. General Condition: Good.

Formula No. 40—Panel No. 168.

Sublimed White Lead 100%	Chalking: Heavy. Checking: Slight. General Condition: Good.

Formula No. 45—Panel No. 170

Zinc Oxide .... 90% Calcium Carbonate 10% 100%	Chalking: Slight. Checking: Slight. General Condition: Good.

Formula No. 46—Panel No. 169.

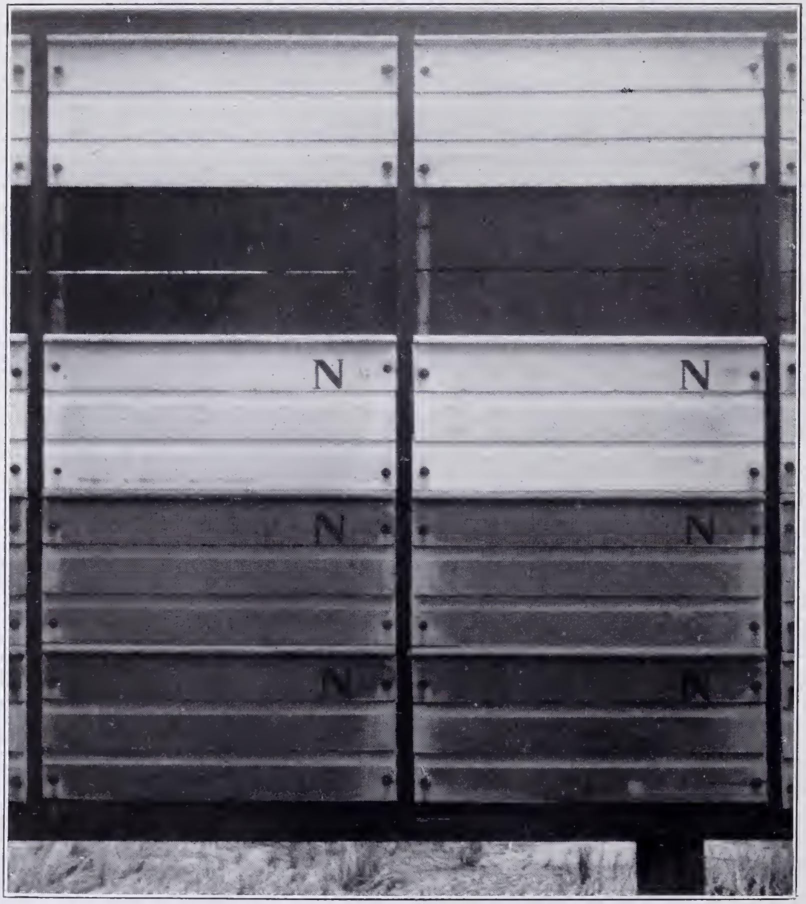
Zinc Oxide .... 61% Barytes 39% 100%	Chalking: Slight. Checking: Medium. General Condition: Fair.

Formula No. 47—Panel No. 172.

Zinc Oxide 100%	Chalking: None.
Ground in special boiled oil.	Checking: Very deep.
	General Condition: Poor

Report on Special Tests Started in 1909 at Pittsburg and at Atlantic City

It will be remembered by those who read the First Annual Report on the Wearing of the Paints Applied to the Test Fences that all the lithophone formulas which were tested failed throughout; the panels on



Appearance of 1909 Tests, Plate No. 2

which these formulas were painted being removed from the fence and discarded from the test. It was suggested by certain members of the American Society for Testing Materials that new lithophone formulas be tested with different percentages of other pigments in combination, to replace the discarded tests. During the months of May and June, 1909 a series of new tests were therefore started, lithophone being mixed with various pigments in ascending proportions.

The use of zinc oxide and calcium carbonate in overcoming the darkening or fogging* of lithopone, preventing its excessive chalking, and increasing its durability, was suggested by several of the lithopone formulas applied in 1907. The results of this year's inspection of the new tests seem to show that a combination of the above-mentioned pigments, namely, lithopone, zinc oxide and whiting, in certain definite proportions, may give paints of some value for general exterior use. Excessive chalking is noted in some of these formulas, but promise of good results is indicated. Before venturing any more definite recommendation, however, it will be advisable to wait for the effect of another year's exposure.

Several grades of the pure white leads, and several high type composite paints were tested out at the same time with the lithopone panels, to act as criterions of the wearing value of the latter. The report of the committee on the condition of each, after one year's exposure follows, in table form. †

The most casual observation of those panels painted with lithopone combined with corroded white lead, shows that these two pigments are

*A brief study of the theory of solutions (See Cushman and Gardner on "Corrosion and Preservation of Iron and Steel"), involving the modes of ion formation, will be invaluable to the student who is inquiring into the cause of the peculiar fogging of lithopone, with the idea in view of correcting this evil by physical or chemical treatment. Inasmuch as our observations thus far have led us to believe that the fogging of lithopone takes place in the presence of moisture, with the contributory and necessary action of chemically active rays from the sun or other source, it is fair to assume that under these conditions the insoluble molecule of zinc sulphide and barium sulphate reverts by intricate molecular disturbance and ionization back to the soluble barium sulphate and zinc sulphide from which the lithopone is formed by metathesis. If this be true, then the acid nature of these soluble salts is no doubt combated and overcome at the moment of formation by the basic nature of zinc oxide and calcium carbonate, which tend to ionize to an alkaline reaction. The value of zinc oxide and calcium carbonate in lithopone paints, as detergents of blackness, has been demonstrated at both Atlantic City and Pittsburg." H. A. G.

† The composition of the vehicle in all the new tests was standard, using pure linseed oil with a small percentage of turpentine drier. The tints used in each formula were secured at the time of application by the use of standard colors, lampblack and medium chrome yellow, using an approximate amount for each formula.

incompatible. It is apparent from a close inspection that the sulphide content of the lithopone has acted on the corroded white lead, with the production of lead sulphide which increases the darkness of the panel's surface.

The formulas which were not properly balanced and which had too high a percentage of lithopone presented a very rough, sandy surface, showing vehicle disintegration. They differed, however, from the surfaces of the corroded lead panels which were rough, in the form of checking, which was of a matted and veined appearance in the case of the lithopone panels.

TESTS INAUGURATED IN 1909

RESULTS OF INSPECTION OF ATLANTIC CITY TEST FENCE, MAY, 1910

Panel No.	FORMULAS: Basic Carbonate White Lead	Zinc Oxide	Basic Sulphate White Lead	Precipitated White Lead	Zinc Lead	Lithopone	INERT PIGMENTS: Calcium Carbonate	Silica	Asbestine	China Clay	Barytes	Blanc Fixe	REPORT OF INSPECTION: Chalking	Checking	General Condition	Remarks	Panel Number
			45			40	15						None	None	Rough surface, but fair for repainting		1
2			45			40		15					None	None	Fair; rough surface and slightly dark		2
3		45				45	10						Very slight	Very slight	Good; very white surface		3
4			45			45	10						None	None	Rough surface and slightly dark		4
		40				40	20						Very slight	Very slight	Good; very white surface		5
6			45			35			20				None	None	Rough surface; dark		6
7	50				36				2	8	4		None	Very slight lateral checking	Good		7
8			50			36			2	8	4		Heavy	Slight	Excellent, very white		8
9			50			36			2		12		Heavy	Some	Excellent, very white		9
10		36	50						2	8	4		None	Slight	Good		10
11	28	55							3		7	7	None	Slight	Good; slightly dark		11
12		55	28						3		7	7	None	Slight lateral	Good		12
13		60				30	10						Very slight	Considerable lateral running along grain of wood	Fair		13
14		30	30			30	10						Very slight	Considerable lateral running along grain of wood	Fair		14
15			60			30			10				Heavy	Slight lateral checking	Fair		15
16						100							Heavy	Considerable	Dark color; rough surface		16
17						100							Considerable	Medium	Better than No. 16; not as rough or dark		17
18	33	33						17		17			Very slight	None	Good		18
19	34	33						33					Very slight	Slight	Good		19
20	34	33								33			Very slight	None	Good		20
21	100												Slight	Slight	Fair; rough surface		21
22	100*												Very slight	Lateral cracking	Fairly good		22
23	100												Medium	Lateral cracking	Fair		23
24			100										Slight	Slight cracking	Good for repainting		24
25					100								Medium	None	Good surface		25
26				100									Heavy	Slight cracking	Fair; surface rough & dark		26
27	100												Heavy	Lateral cracking	Fair		27
28	100												Medium	Considerable	Poor; very rough, dark surface		28
29	24	45	13						18				Slight	None	Good		29
30	45					40	15						Heavy	Heavy checking and alligatoring	Poor		30
31	45					40		15					None	Alligatoring	Rough surface; dark		31
32	45					35			20				Slight	Medium	Dark and rough surface		32
33	50					36			2		12		Considerable	Slight	Poor; dark surface		33
34	75		25										None	None	Fair; dark surface		34
35	50		50										None	Slight	Fair; rough surface		35
36								100					Extremely bad	Medium	Fair	Vehicle disintegrated; spotted in places	36

* This pigment on analysis proved to be zinc lead. See Report on Analysis.

Inspection of 1909 Test, Atlantic City

Formula No. 1—Panel No. 1.

Lithopone	40%	Chalking: None.
Basic Sulphate—White Lead	45%	Checking: None.
Calcium Carbonate	15%	General Condition: Rough surface but fair for repainting.
	100%	

Formula No. 2—Panel No. 2.

Lithopone	40%	Chalking: None.
Basic Sulphate—White Lead	45%	Checking: None.
Silica	15%	General Condition; Fair Rough surface and slightly dark.
	100%	

Formula No. 3—Panel No. 3.

Lithopone	45%	Chalking: Very Slight.
Zinc Oxide	45%	Checking: Very Slight.
Calcium Carbonate	10%	General Condition: Good, very white surface.
	100%	

Formula No. 4—Panel No. 4.

Lithopone	45%	Chalking: None.
Basic Sulphate—White Lead	45%	Checking: None.
Calcium Carbonate	10%	General Condition: Rough surface and slightly dark.
	100%	

Note.—Panels 3, 5, 7, 8, 9, 12, 13, 14, 15, 17, 29 and 30 were very white on the 1909 tests at Atlantic City, N. J. Panels 8 and 9 were extremely white. Panels 31, 32, 33 and 34 were very dark. The balance of the panels were quite dark. In these same tests, namely, the 1909 tests, Panels 1, 2, 3, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 21 showed the best color maintenance in the yellows and the grays.

Formula No. 5—Panel No. 5.

Lithopone	40%	Chalking: Very Slight.
Zinc Oxide	40%	Checking: Very Slight.
Calcium Carbonate	20%	General Condition: Good. Very white surface.
	100%	

Formula No. 6—Panel No. 6.

Lithopone	35%	Chalking: None.
Basic Sulphate—White Lead	45%	Checking: None.
Asbestine	20%	General Condition: Rough surface Dark.
	100%	

Formula No. 7—Panel No. 7.

Basic Carbonate — White Lead	50%	Chalking: None.
Zinc Lead	36%	Checking: Very Slight Lateral checking.
China Clay	8%	General Condition: Good.
Barytes	4%	
Asbestine	2%	
	100%	

Formula No. 8—Panel No. 8.

Basic Sulphate—White Lead	50%	Chalking: Heavy.
Lithopone	36%	Checking: Slight.
China Clay	8%	General Condition: Excellent. Very white.
Barytes	4%	
Asbestine	2%	
	100%	

Formula No. 9—Panel No. 9.

Basic Sulphate—White Lead	50%	Chalking: Heavy.
Lithopone	36%	Checking: Some.
Barytes	12%	General Condition: Excellent. Very white.
Asbestine	2%	
	100%	

Formula No. 10—Panel No. 10.

Basic Sulphate—White Lead	50%	Chalking: None.
Zinc Oxide	36%	Checking: Slight.
China Clay	8%	General Condition: Good.
Barium Sulphate	4%	
Asbestine	2%	
	100%	

Formula No. 11—Panel No. 11.

Basic Carbonate — White Lead	28%	Chalking: None.
Zinc Oxide	55%	Checking: Slight.
Blanc Fixe	7%	General Condition: Good. Slightly dark.
Barytes	7%	
Asbestine	3%	
	100%	

Formula No. 12—Panel No. 12.

Basic Sulphate—White Lead	28%	Chalking: None.
Zinc Oxide	55%	Checking: Slight Lateral.
Blanc Fixe	7%	General Condition: Good.
Barytes	7%	
Asbestine	3%	
	100%	

Formula No. 13—Panel No. 13.

Lithopone	30%	Chalking: Very slight.
Zinc Oxide	60%	Checking: Considerable Lateral running along grain of wood.
Calcium Carbonate	10%	General Condition: Fair.
	100%	

Formula No. 14—Panel No. 14.

Lithopone	30%	Chalking: Very Slight.
Zinz Oxide	30%	Checking: Considerable Lateral checking running along grain of wood.
Basic Sulphate—White Lead	30%	General Condition: Fair.
Calcium Carbonate	10%	
	100%	

Formula No. 15—Panel No. 15.

Lithopone	30%	Chalking: Heavy.
Basic Sulphate—White Lead	60%	Checking: Slight Lateral checking.
Asbestine	10%	General Condition: Fair.
	100%	

Formula No. 16—Panel No. 16.

Lithopone	100%	Chalking: Heavy.
Ground in linseed oil with 5% chrome resinate.		Checking: Considerable. General Condition: Dark color; rough surface.

Formula No. 17—Panel No. 17.

Lithopone	100%	Chalking: Considerable.
Ground in linseed oil with 2% zinc resinate to be thinned for spreading with turpentine and spar varnish for high gloss.		Checking: Medium. General Condition; Better than No. 16. Not as rough or dark.

Formula No. 18—Panel No. 18.

Basic Carbonate — White Lead	33%	Chalking: Very Slight. Checking: None.
Zinc Oxide	33%	General Condition: Good.
Silica	17%	
Kaolin	17%	
	100%	

Formula No. 19—Panel No. 19.

Basic Carbonate — White Lead	34%	Chalking: Very Slight. Checking: Slight.
Zinc Oxide	33%	General Condition: Good.
Silica	33%	
	100%	

Formula No. 20—Panel No. 20.

Basic Carbonate — White Lead	34%	Chalking: Very Slight. Checking: None.
Zinc Oxide	33%	General Condition: Good.
Kaolin	33%	
	100%	

Formula No. 21—Panel No. 21.

Basic Carbonate — White Lead ....100% S.	Chalking: Slight. Checking: Slight. General Condition: Fair. Rough surface.

Formula No. 22*—Panel No. 22.

Basic Carbonate — White Lead ....100% E.	Chalking: Very Slight. Checking: Lateral cracking. General Condition: Fairly good.

Formula No. 23—Panel No. 23.

Basic Carbonate — White Lead ....100% C.	Chalking: Medium. Checking: Lateral cracking. General Condition: Fair.

Formula No. 24—Panel No. 24.

Basic Sulphate — White Lead 100%	Chalking: Slight. Checking: Slight cracking. General Condition: Good for re-painting.

Formula No. 25—Panel No. 25.

Zinc Lead 100%	Chalking: Medium. Checking: None. General Condition: Good surface.

Formula No. 26—Panel No. 26.

Precipitated White Lead..100% M.	Chalking: Heavy. Checking: Slight cracking. General Condition: Fair. Surface rough and dark.

Formula No. 27—Panel No. 27.

Basic Carbonate — White Lead ....100% Mild process.	Chalking: Heavy. Checking: Lateral cracking. General Condition: Fair.

*This pigment on analysis proved to be zinc lead white. See Report on Analysis.

Formula No. 28—Panel No. 28.

Basic Carbonate — White Lead .... 100% B.-B.	Chalking: Medium. Checking: Considerable. General Condition: Poor. Very rough, dark surface.

Formula No. 29—Panel No. 29.

Basic Carbonate — White Lead	24%	Chalking: Slight.
Basic Sulphate—White Lead	13%	Checking: None.
Zinc Oxide	45%	General Condition: Good.
Asbestine	18%	
	100%	

Formula No. 30—Panel No. 30.

Lithopone	40%	Chalking: Heavy.
Basic Carbonate — White Lead	45%	Checking: Heavy checking and alligatoring.
Calcium Carbonate	15%	General Condition: Poor.
	100%	

Formula No. 31—Panel No. 31.

Lithopone	40%	Chalking: None.
Basic Carbonate — White Lead	45%	Checking: Alligatoring.
Silica	15%	General Condition: Rough surface. Dark.
	100%	

Formula No. 32—Panel No. 32.

Lithopone	35%	Chalking: Slight.
Basic Carbonate — White Lead	45%	Checking: Medium.
Asbestine	20%	General Condition: Dark and rough surface.
	100%	

Formula No. 33—Panel No. 33.

Lithopone 36%	Chalking: Considerable.
Basic Carbonate — White Lead 50%	Checking: Slight.
Barytes 12%	General Condition: Poor. Dark surface.
Asbestine 2%	
100%	

Formula No. 34—Panel No. 34.

Basic Carbonate — White Lead 75%	Chalking: None.
Basic Sulphate—White Lead 25%	Checking: None.
100%	General Condition: Fair. Dark surface.

Formula No. 35—Panel No. 35.

Basic Sulphate—White Lead 50%	Chalking: None.
Basic Carbonate — White Lead 50%	Checking: Slight.
100%	General Condition: Fair. Rough surface.

Formula No. 36—Panel No. 36.

Silica 100%	Chalking: Extremely bad.
	Checking: Medium.
	General Condition: Fair.
	Remarks: Vehicle disintegrated. Spotted in places.

Repainting Tests in 1910 at Atlantic City

Repainting tests were made during May, 1910, on the first set of tests, painted originally in 1907. The work was in charge of Mr. George Butler, the master painter representing the Philadelphia Master Painters' Association. who had charge of the painting of all the tests placed on the Atlantic City Test Fence. The Scientific Section was represented by H. A. Gardner, who was constantly in attendance during the application of the paints in the new test, supervising the reductions and keeping the records.

Previous to repainting the panels, the small sections which had been used in the laboratory for microscopic work, were returned to their respective positions. Each panel was lightly sandpapered and brushed free from adhering dirt, sand or scale. Two coats of white paint were applied on each white pine panel; the yellow and gray tints of paint, and the other grades of wood being omitted from the test. The paints were furnished in sealed packages properly numbered and tabulated, being part of the original supply and of the same composition as used in the first test during 1907. The usual careful method of carrying on field tests was observed in the repainting tests. An inspection of these repainted surfaces will be made next year, and it is assumed that considerable data therefrom will at that time be obtainable.

Analysis of Paint Pigments Applied to the Pittsburg and Atlantic City Test Fences, June, 1909

Pittsburg, Pa., April 11, 1910.

MR. HENRY A. GARDNER, Director.
Scientific Section, Paint Manufacturers' Association of the U. S.,
3500 Gray's Ferry Road, Philadelphia, Pa.

Dear Sir—

I herewith submit the analyses made by Dr. Stevens and myself of the paints placed on the Pittsburg and Atlantic City Test Fences during June, 1909.

The oil was extracted from the paints by repeated centrifuging with benzine. The small amount of oil which remained, and the soap which had formed on standing were deducted from the pigments, which were then calculated to 100%. This unextracted matter ran approximately 2% in each case.

Repeated analyses were made in each case, so as to get absolute confirmation of results.

Very truly yours,
DR. JOHN A. SCHAEFFER,
Carnegie Technical Schools, Pittsburg, Pa.

Formula No.	Supposed Composition		Found on Analysis
1—	Lithopone	40%	41.67%
	Basic Sulphate—White Lead	45%	43.86%
	Calcium Carbonate	15%	14.47%
		100%	100.00%
2—	Lithopone	40%	41.31%
	Basic Sulphate—White Lead	45%	43.45%
	Silica	15%	15.24%
		100%	100.00%

Formula No.	Supposed Composition		Found on Analysis
3—	Lithopone	45%	43.39%
	Zinc oxide	45%	45.32%
	Calcium Carbonate	10%	11.29%
		100%	100.00%
4—	Lithopone	45%	48.10%
	Basic Sulphate—White Lead	45%	42.83%
	Calcium Carbonate	10%	9.07%
		100%	100.00%
*5—	Lithopone	40%	46.44%
	Zinc Oxide	40%	27.36%
	Calcium Carbonate	20%	26.20%
		100%	100.00%
6—	Lithopone	35%	35.47%
	Basic Sulphate—White Lead	45%	44.43%
	Asbestine	20%	20.10%
		100%	100.00%
7—	Basic Carbonate—White Lead	50%	53.22%
	Zinc Lead	36%	36.00%
	China Clay	8%	7.74%
	Barytes	4%	2.00%
	Asbestine	2%	1.04%
		100%	100.00%
8—	Basic Sulphate—White Lead	50%	50.26%
	Lithopone	36%	35.34%
	Clay	8%	8.36%
	Barytes	4%	3.64%
	Asbestine	2%	2.40%
		100%	100.00%

*On account of the formation of zinc compounds with the vehicle and subsequent oxidation, it was impossible to make a satisfactory extraction of No. 5, as part of the vehicle was solid at ordinary temperatures and liquid at 100 degrees. After repeated attempts the above analysis is submitted as the best obtainable.

Formula No.	Supposed Composition		Found on Analysis
9—	Basic Sulphate—White Lead..	50%	47.35%
	Lithopone	36%	38.09%
	Barytes	12%	12.00%
	Asbestine	2%	2.56%
		100%	100.00%
10—	Basic Sulphate—White Lead..	50%	48.30%
	Zinc Oxide	36%	37.39%
	China Clay	8%	7.96%
	Barytes	4%	4.26%
	Asbestine	2%	2.09%
		100%	100.00%
11—	Basic Carbonate—White Lead	28%	30.45%
	Zinc Oxide	55%	54.77%
	Blanc Fixe	7%	12.08%
	Barytes	7%	
	Asbestine	3%	2.70%
		100%	100.00%
12—	Basic Sulphate—White Lead..	28%	27.57%
	Zinc Oxide	55%	57.99%
	Blanc Fixe	7%	12.35%
	Barytes	7%	
	Asbestine	3%	2.09%
		100%	100.00%
13—	Lithopone	30%	33.20%
	Zinc Oxide	60%	57.90%
	Calcium Carbonate	10%	8.90%
		100%	100.00%
14—	Lithopone	30%	30.73%
	Zinc Oxide	30%	31.55%
	Basic Sulphate—White Lead..	30%	27.68%
	Calcium Carbonate	10%	10.04%
		100%	100.00%

Formula No.	Supposed Composition		Found on Analysis
15—	Lithopone	30%	36.40%
	Basic Sulphate—White Lead	60%	54.39%
	Calcium Carbonate	10%	9.21%
		100%	100.00%
16—	Lithopone	100%	Lithopone........100.00%
			Barium Sulphate ..71.95%
			Zinc Sulphide 25.52%
			Zinc Oxide 2.53%
17—	Lithopone	100%	Lithopone........100.00%
			Barium Sulphate ..71 85%
			Zinc Sulphide 24.90%
			Zinc Oxide 3.25%
18—	Basic Carbonate—White Lead	33%	33.90%
	Zinc Oxide	33%	33.70%
	Silica	17%	32.40%
	China Clay	17%	
		100%	100 00%
19—	Basic Carbonate—White Lead	34%	35.49%
	Zinc Oxide	33%	29.60%
	Silica	33%	34.91%
		100%	100.00%
20—	Basic Carbonate—White Lead	34%	33.34%
	Zinc Oxide	33%	33.24%
	Clay	33%	33.42%
		100%	100.00%
21—	Basic Carbonate—White Lead. Type S.	100%	Basic Carbonate—White Lead 100.00%
22—	Basic Carbonate—White Lead.	100%	Zinc Lead 100.00%
			Zinc Oxide 47.30%
			Lead Sulphate.....52.70%
			100.00%
23—	Basic Carbonate—White Lead. Type C.	100%	Basic Carbonate—White Lead 100.00%

Formula No.	Supposed Composition		Found on Analysis
24	Basic Sulphate—White Lead..100%		Basic Sulphate—White Lead ...100.00%
		Basic Sulphate—White Lead 89.36%	
		Zinc Oxide 10.64%	
		100.00%	
25	Zinc Lead 100%		Zinc Lead 100%
		Zinc Oxide 50.14%	
		Lead Sulphate ... 49.86%	
		100.00%	
26	Basic Carbonate—White Lead.100% Type M.		Basic Carbonate—White Lead 100.00%
27	Basic Carbonate—White Lead.100% Mild Process.		Basic Carbonate—White Lead 100.00%
28	Basic Carbonate—White Lead.100% B. B.		Basic Carbonate—White Lead 100.00%
29	Basic Carbonate—White Lead 24%		25.52%
	Basic Sulphate—White Lead.. 13%		14.77%
	Zinc Oxide 45%		44.66%
	Asbestine 18%		15 05%
	100%		100 00%
30	Lithopone 40%		39.59%
	Basic Carbonate—White Lead 45%		48.43%
	Calcium Carbonate 15%		12 08%
	100%		100.00%
31	Lithopone 40%		39.81%
	Basic Carbonate—White Lead 45%		44.92%
	Silex 15%		15.27%
	100%		100.00%
32	Lithopone 35%		36.78%
	Basic Carbonate—White Lead 45%		44.99%
	Asbestine 20%		18.23%
	100%		100.00%

Formula No.	Supposed Composition		Found on Analysis
33—	Lithopone 36%		36.00%
	Basic Carbonate—White Lead 50%		51.26%
	Barytes 12%		10.80%
	Asbestine 2%		1.94%
	100%		100.00%
34—	Basic Carbonate—White Lead 75%		83.00%
	Basic Sulphate—White Lead.. 25%		17.00%
	100%		100.00%
35—	Basic Sulphate—White Lead.. 50%		34.09%
	Basic Carbonate—White Lead 50%		65.91%
	100%		100.00%
36—	Silica 100%		
		Silica 95.00%	
		Barytes 3.78%	
		Alumnia 1.22%	
		100.00%	

CATALOGUE

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Proceedings of the American Society for Testing Materials—11th Annual Meeting.

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Report of Tariff Committee, Paint Manufacturers' Association of the United States, 1909.

Rustless Coatings, Corrosion and Electrolysis of Iron and Steel —*M. P. Wood*

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A Handbook on Paints, Colors and Varnishes

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The Volatile Oils —*Gildmeister and Hoffman*
Transactions of the American Electrochemical Society, 1909.
Pamphlets
- Corrosion of Fence Wire —*A. S. Cushman*
- The Analysis of Turpentine by Fractional Distillation with Steam —*Wm. C. Geer*
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- Oil, Paint and Drug Reporter
- The American Paint and Oil Dealer
- The Canadian Painter and Decorator
- The Decorator
- The Master Painters' Journal
- The Painters' Magazine

Publications of the Scientific Section

EDUCATIONAL BUREAU

PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

Bulletin Number

Preliminary Booklet—Addresses on Paint, Delivered Before the Michigan Chapter, American Institute of Architects, 1907. (*Out of print.*)

1—Tables of White Pigments and Vehicle—Standard Nomenclature.

2—Standard Can Sizes Recommended to Paint Manufacturers.

3—First Report on the Test Fences Erected by the Scientific Section. (*Out of print.*)

4—Methods for the Analysis of the Vehicle Constituents of Paint. (*Out of print.*)

5—Tests Upon the Corrosion of Iron to be Conducted by the Scientific Section. (*Out of print.*)

6—First Annual Report of the Scientific Section.

7—Preliminary Report on Steel Test Fences.

8—Report of Committee "E" on Preservative Coatings for Iron and Steel. (*Out of print.*)

9—Recent Technical Developments in Paint Manufacture.

10—Protective Coatings for Conservation of Structural Material.

11—The Corrosion of Iron and Steel. *By Alfred Sang.* (*Out of print.*)

12—The Function of Oxygen in the Corrosion of Metals. *By William H. Walker.*

Bulletin
Number

13—Protective Coatings for Steel and Iron. *By Robert S. Perry.* (*Out of print.*)

14—Coatings for the Conservation of Structural Material. (*Out of print.*)

15—Protective Coatings for Structural Material. *By R. S. Perry.*

16—First Annual Report on Wearing of Paints Applied to Atlantic City Test Fence.

17—First Annual Report on Wearing of Paints Applied to Pittsburg Test Fence.

18—First Annual Report on Atlantic City Steel Test Fence.

19—Laboratory Study of Panels on Atlantic City and Pittsburg Test Fences. (*Out of print.*)

20—Concrete Coatings. *By H. A. Gardner.*

21—A Brief Talk on Paints. *By Henry A. Gardner.* (*Out of print.*)

22—Annual Report for 1909.

Preliminary Bulletin—Second Edition—Physical Characteristics of a Paint Coating. *By R. S. Perry.*

23—The Theory of Driers, Etc.

24—Some Iron Oxides and Their Values.

25—Report on Examination of North Dakota Test Fences.

Special Bulletin—Scientifically Prepared Paints and Laws Governing Their Manufacture. *By Henry A. Gardner.*

An Exhibition of Certain Analogies Governing the Manufacture of Concrete and of Paint. *By R. S. Perry.*

26—Second Annual Report on Wearing of Paints Applied to Atlantic City Test Fence.

27—Second Annual Report on Atlantic City Steel Test Fence

28—Second Annual Report on Wearing of Paints Applied to Pittsburg Test Fence.

Bulletin No. 26 Summary

Second Annual Report

on Wearing of Paints Applied to Atlantic City Test Fence

Atlantic City Test Fence

Scientific Section–Educational Bureau
Henry A. Gardner, Director
Paint Manufacturers' Association of the United States
Philadelphia, Pa.

Second Annual Report

on

Wearing of Paints Applied

to

Atlantic City Test Fence

Scientific Section—Educational Bureau
Henry A. Gardner, Director
Paint Manufacturers' Association
of the United States
PHILADELPHIA, PA.

PREFACE

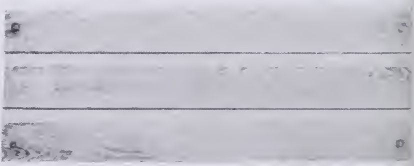
This report, made by the joint committees represented in the test, sums up in a final manner the results obtained. The ability of the master painter and architect to avail themselves of the facts garnered from these tests and to apply them in their specifications has been fairly commensurate with the great strides of progress and improvement which these tests have effected in the painting industry.

A complete detailed report of the wearing of each formula in the test can be obtained by writing to the Scientific Section for the original Bulletin No. 26, of which this pamphlet is but a summary in reduced fac-simile form.

HENRY A. GARDNER,
Director.

Combination Pigment Paint

Single Pigment Paint



Cuts Showing Good Condition of Combination Type of Paint vs. Single Pigment Type

Summary of Report

The second annual inspection of the paints applied to the Atlantic City test fence was made on May 10th, 1910, by a committee representing the Master Painters' Association of Philadelphia and the Scientific Section of the Paint Manufacturers' Association of the United States.

The painted panels were all carefully inspected by the inspectors in the usual manner. With the aid of high-power magnifying glasses, checking was determined. The degree of chalking exhibited by the various paints was ascertained by rubbing a piece of black cloth across the surface of each paint. Close observance was made to determine scaling, peeling, cracking, gloss, color and the other factors to be considered when examining a painted surface. From these observations it was possible for the inspectors to

state whether a panel exhibited general good condition, general fair condition or general poor condition.

An inspection of the white lead paints on the fence indicated in every instance a rough, chalked and disintegrated surface that seemed to be well worn, in some cases nearly to the wood. The strongly oxidizing air of the seacoast is probably responsible for the early decay of this pigment.

There are no pigments possessing greater hiding properties when first used than white leads, but the lack of hiding power on the white lead panels after two years' exposure was caused by the chalking away of the lead. The superior hiding power of the composite paints was due to the action of the other pigments in these combination paints in preventing the lead from chalking away.

The Committee finds that the addition of a reasonable percent-

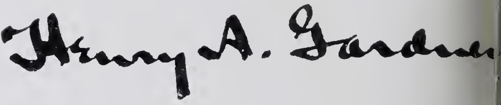
age of zinc oxide to white lead increases its durability and retards its chalking, renders it whiter, and forms a surface that presents a much better repainting condition. The combinations of white lead and zinc oxide on the Atlantic City test fence were in general good condition throughout.

Corroded white lead, sublimed white lead, zinc oxide, and zinc lead are the standard white opaque pigments. They were all tested on the Atlantic City fence and it was found that to use any one alone results in inferior protection to the wood. Barium sulphate, silica, asbestine, china clay, and calcium carbonate are the standard crystalline pigments. In the past, the overloading of paints with these crystalline or inert pigments has been the cause of the prejudice that painters have had against their use. It has been established beyond controversy, however, that the use of these pigments, in moderate percentage, combined with any of the standard opaque white pigments, such as white leads, zinc oxide, etc., undoubtedly results in better

service from every standpoint and forms the most satisfactory white paint for general outside use. Some of the most perfect painted surfaces on the fence were those made on the above basis as reference to the charted report will show.

Official Painter Atlantic City Test Fence, Representing Philadelphia Master Painters' Association

Master Painter



Director Scientific Section

Bulletin No. 27

Second Annual Report on Atlantic City Steel Test Fence

THE INSPECTION PARTY AT WORK

Scientific Section—Educational Bureau

HENRY A. GARDNER, Director

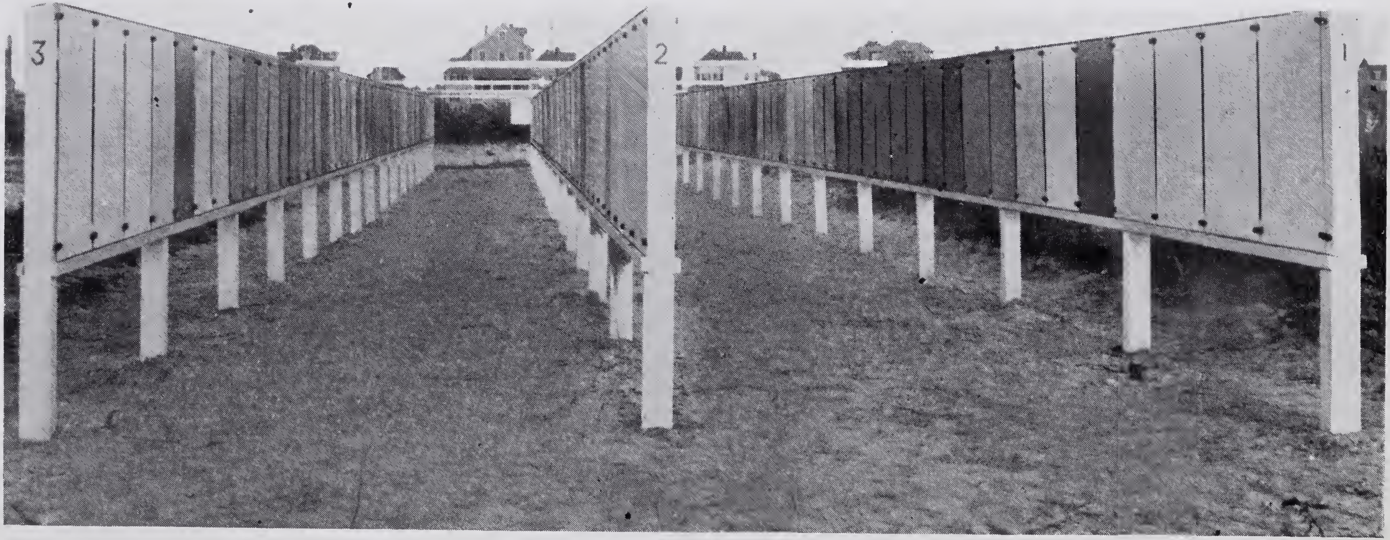
PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

Philadelphia, Pa.

SECOND ANNUAL REPORT on Atlantic City Steel Test Fence

SCIENTIFIC SECTION—EDUCATIONAL BUREAU
HENRY A. GARDNER, Director

PAINT MANUFACTURERS' ASSOCIATION
OF THE UNITED STATES
Philadelphia, Pa.



A SIDE VIEW OF STEEL TEST FENCES

PREFACE

The following report on the condition of the painted steel panels erected in October, 1908, at Atlantic City, N. J., and inspected during April, 1910, is the first detailed report on these tests published by the Scientific Section.

The tests were under the supervision and inspection of a joint committee representing Committees E and U of the American Society for Testing Materials, of which Dr. Allerton Cushman is chairman. The results of the inspection made by the above societies are separate and distinct from the report published herewith, and will probably be presented at the June meeting of the Society. The following report is made with a view of presenting the matter in a more detailed way for the use of members of this Association.

The methods followed during the application of the paints and other information regarding the work will be found in the appendix to this bulletin. (See Page 23.) The tests will be continued and possibly supplemented during the next two years, when subsequent reports will be issued, if further results of interest have developed.

Although this Bulletin will not present any lengthy discussion of the results, there are a few points of interest apparent even to the most casual observer of the tests, and these points will be treated of as briefly as possible.

It is evident that iron and steel demands immediate protection in order to prevent corrosion. It is also evident that as good results may be obtained on one grade of steel as on another, provided the same paint is used. Inequalities of treatment in steel manufacture, segregation of impurities and presence of mill scale will all tend to excite corrosion when the paint has failed, but when the paint protects the surface, these factors have probably very little effect.

The fine showing of the inhibitive type of pigments is very gratifying and points out the path for the manufacturers to follow in compounding protective paints. The use of small quantities of high-

power inhibitive pigments, such as zinc chromate, together with combinations of the other standard pigments of the opaque and crystalline variety, is recommended from these tests, and no doubt will be followed by the careful and conscientious producer.

Inasmuch as the plates of bare, unpainted iron of different types which were exposed, were not weighed at the time of erection, no report will be made of their condition, except to state that those covered with mill scale are showing more pitting and rougher surfaces than the others.

HENRY A. GARDNER,
Director.

REPORT

Plate No. 1.—Dutch Process White Lead.

In fairly good condition. Color slightly dark. Chalking which had proceeded very rapidly at first has diminished, leaving a thinner coating of less hiding power and more easily penetrable by water. Corrosion not apparent until paint coating is removed, when a thin layer of iron rust appears.

Corrosion Adhering to Film Stripped from Panel Painted With Corroded White Lead

Plate No. 2—Quick Process White Lead.

Same condition as No. 1.

Photomicrographs of Three Grades of Steel Unpainted, Showing Different Forms of Rusting

Plate No. 3—Zinc Oxide.

This panel is covered with thin lateral streaks of rust. The zinc oxide film was brittle and cracking resulted. Moisture penetrated the cracks and caused corrosion. Removal of film shows steel exceptionally bright, except where cracks have formed.

1000 grams of this paint required 170 grams of turpentine to thin to painting consistency. The paste was very heavy and had insufficient oil for good results. Zinc Oxide combined with other pigments and sufficient oil has given good service.

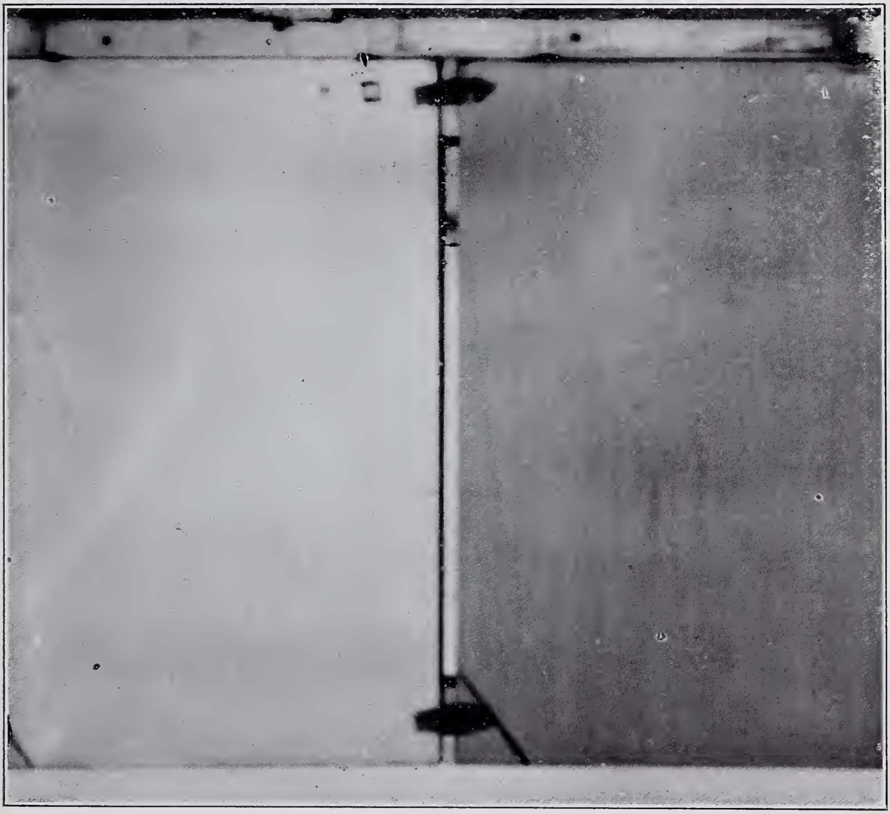
Plate No. 4—Sublimed White Lead.

This pigment has chalked heavily and progressively, but the chalked pigment has not washed off and the surface remains white

and chalky. No checking or corrosion apparent, either before or after removal of film. Film very elastic.

Plate No. 5—Sublimed Blue Lead.

Same as No. 4. Color has lightened and faded gray.



Good Condition of Sublimed White and Blue Lead

Plate No. 6—Lithopone.

Pigment has destroyed vehicle, causing early and excessive chalking. Corrosion is very apparent and a slight pinkish tinge pervades the previously white surface. Roughness characteristic of lithopone exposed outside, is showing.

Plate No. 7—Zinc Lead White.

In general good condition, with the exception of the color which is slightly dark. Medium chalking. No checking or corrosion apparent.

Plate No. 9—Orange Mineral American.

In excellent general condition, showing good, firm surface with no checking, chalking or corrosion. Color has, however, whitened to a great degree and indicates action with the carbonic acid of the atmosphere, forming lead carbonate or ordinary white lead on the surface.

Plate No. 10—Red Lead.

Same as No. 9.

Plate No. 12—Bright Red Oxide.

In generally fair condition. Very slight corrosion only, under surface of film.

Plate No. 14—Venetian Red.

Not as good condition as No. 12. Corrosion apparent beneath film, with several small wart-like eruptions.

Plate No. 15—Prince's Metallic Brown.

Same as No. 14.

Plate No. 16—Natural Graphite.

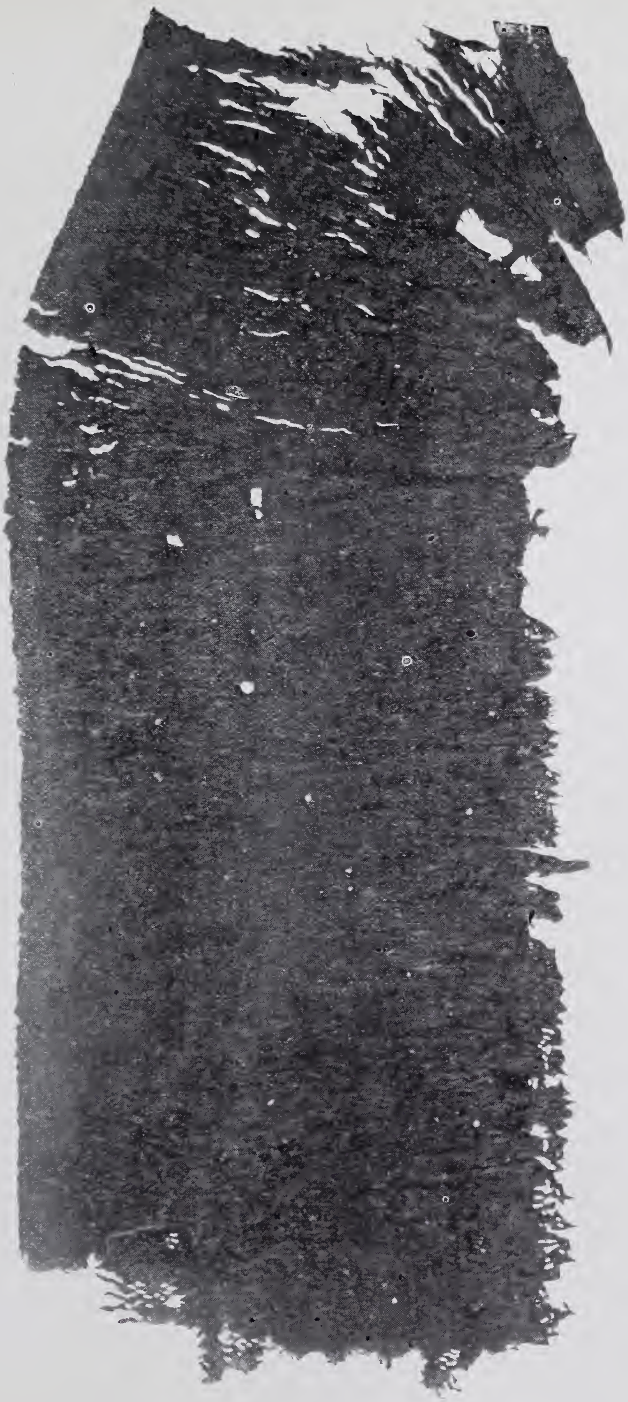
Film intact and elastic, except in spots where several abrasions appeared with the formation of deep rust pits. Corrosion beneath film slight and of surface nature.

Plate No. 17—Acheson Graphite.

Same as No. 16.

Paint Stripped from One-Half Surface of Plate Painted with Metallic Brown. Slight Corrosion Apparent.

Corrosion Pits on Graphite Panel



Rust on Stripped Graphite Film

Plate No. 19—Lampblack and Barytes*.

Film intact and elastic. Abrasions on surface showed stimulated corrosion effects of pronounced nature.

Pigment consists of 10.03 lbs. barytes and 1.39 lbs. carbon black to gallon of oil.

Plate No. 20—Willow Charcoal.

In general good condition throughout. Very slight corrosion only beneath film.

Plate No. 21—Carbon Black and Barytes*.

Film elastic and well preserved. Slight abrasions where metal was exposed showed deep pitting.

Pigment portion consisted of 8.9 lbs. barytes and 1.8 lbs. lampblack to gallon of oil.

Plate No. 24—Ochre.

Very bad condition. Mottled appearance with eruptions of rust showing through surface of the film. Metal beneath film corroding superficially.

Plate No. 27—Natural Barytes.

Bad appearance of surface. with pinholed film and corrosion apparent. This same pigment in combination with lampblack and graphite gave much better results.

Plate No. 28—Blanc Fixe.

Same as No. 27, with considerable more chalking and disintegration.

Plate No. 29—Whiting.

Early and rapid chalking completely destroyed film, which soon split off, leaving the entire steel plate bare. Alkaline nature of pigment, however, has evidently made steel somewhat passive, as rusting is of a superficial nature.

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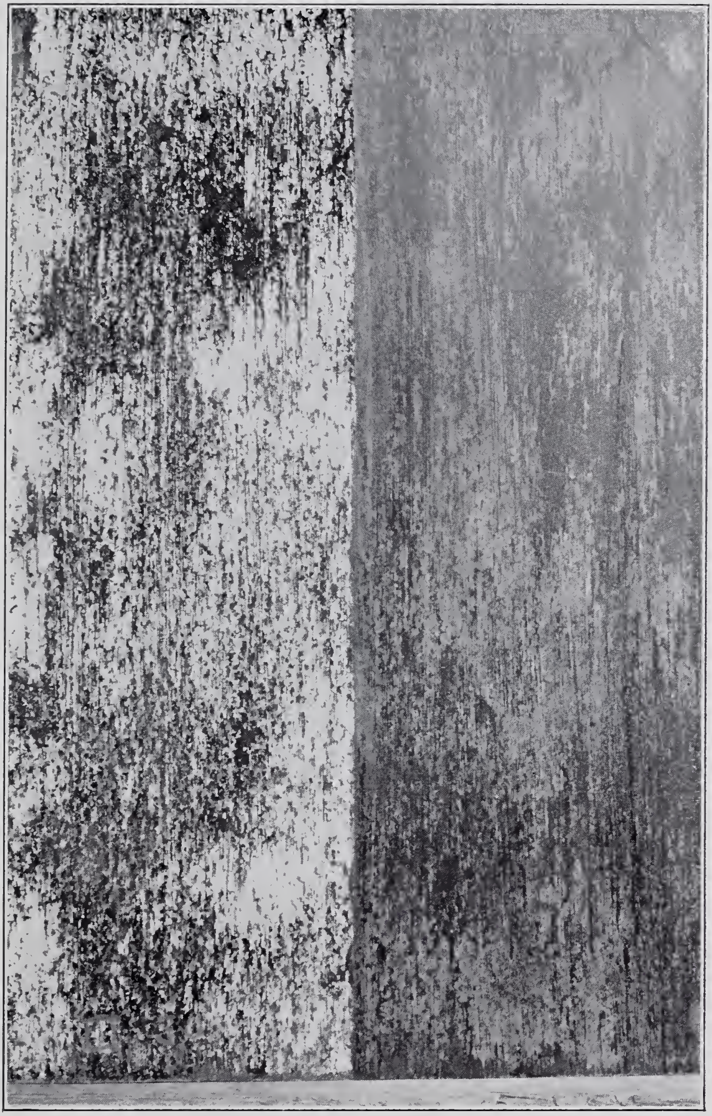
*Pigments Nos. 19 and 21, because of their excessive oil carrying properties, required the addition of barytes to conform to the standard pigment-in-oil formula adopted:

Sp. Gr. of Pigment $\times$ 3 = lbs. Pigment to Gallon of Oil.



Panel Painted with Blanc Fixe. Right Side Stripped of Paint to Show Corrosion

Plates Showing Effect of Chemically Active Pigments on Oil
After One Year's Wear

Plate No. 30—Precipitated Calcium Carbonate.

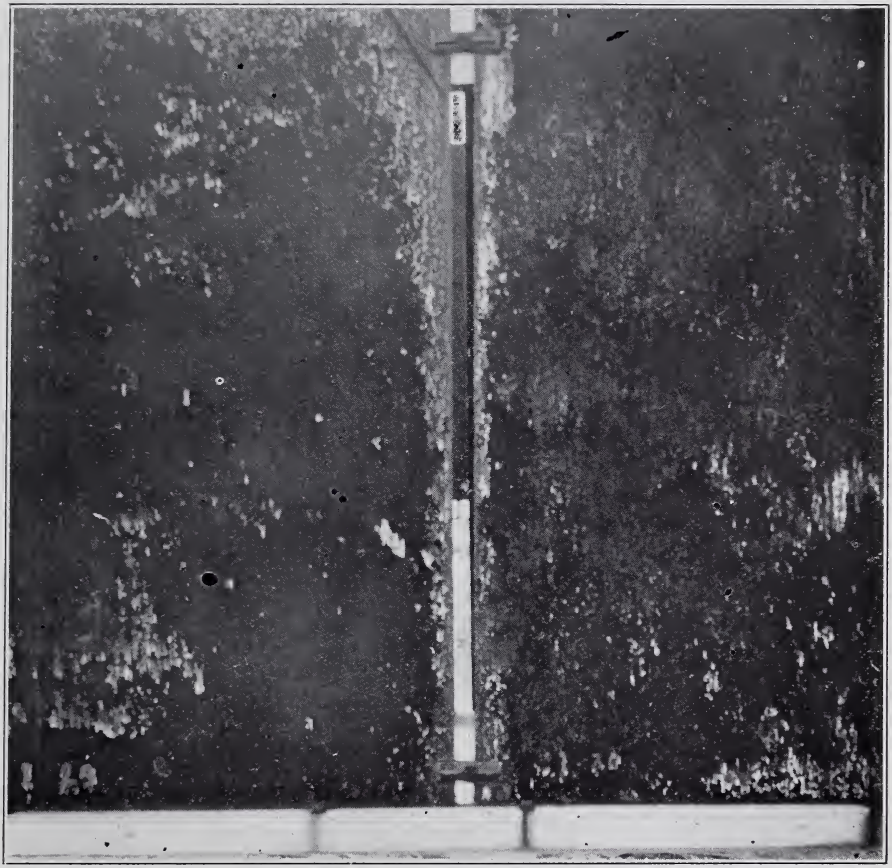
More rapid destruction ensued than in No. 29.

Plate No. 31—Calcium Sulphate.

Soluble nature of pigment acted upon by deposited moisture, with washing effect. Film proved a very poor excluder and rusting beneath film started soon after tests. Dark film of rust apparent now, but paint film is intact.

Plate No. 32—China Clay.

Good condition. Film intact and hard, with no checking or chalking. Slight corrosion only.



Chemically Active Pigments and Their Effect After Eighteen Month's Wear

Plate No. 33—Asbestine.

Same as No. 32.

Plate No. 34—American Vermilion (Basic Chromate of Lead).

This pigment has given perfect protection to the steel. The film is strong and elastic and upon removal reveals the bright steel surface. The inhibitive characteristics of this pigment are pronounced.

Plate No. 36—Lead Chromate.

Generally fair condition. Some checking and very slight splitting in places.

Corrosion Adhering to Film Stripped from Panel Painted with Gypsum (Calcium Sulphate)

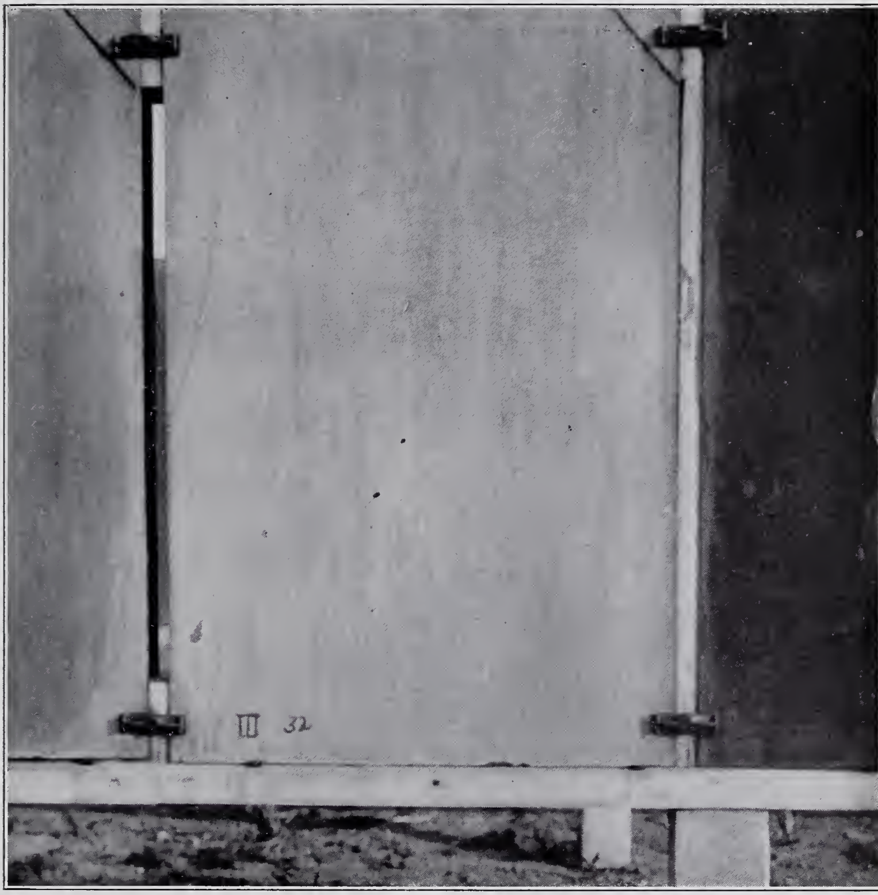
Plate No. 39—Zinc Chromate.

This pigment presents a perfect appearance with decided maintenance of color, elasticity of film and freedom from any bad characteristics. The steel beneath is as bright as when painted. The inhibitive tendencies of this pigment are remarkable.

Plate No. 40—Zinc and Barium Chromate.

Almost as good as No. 39. Color much lighter and not as pleasing, however.

NOTE.—Attention has been called lately to some tests conducted by a New York engineer, wherein a series of small test plates, about four inches square, were painted with commercial paints submitted by various paint concerns. The results of these tests did not place the so-called "chromate paints" as the best. There were no real inhibitive chromate tests upon the market at the time these tests were started, and the composition of the paints reported on were not known. The tests, therefore, are of little value. To conduct tests on any material, large sized plates should be used, and the paints applied in a thoroughly practical way; not with a small bristle brush.



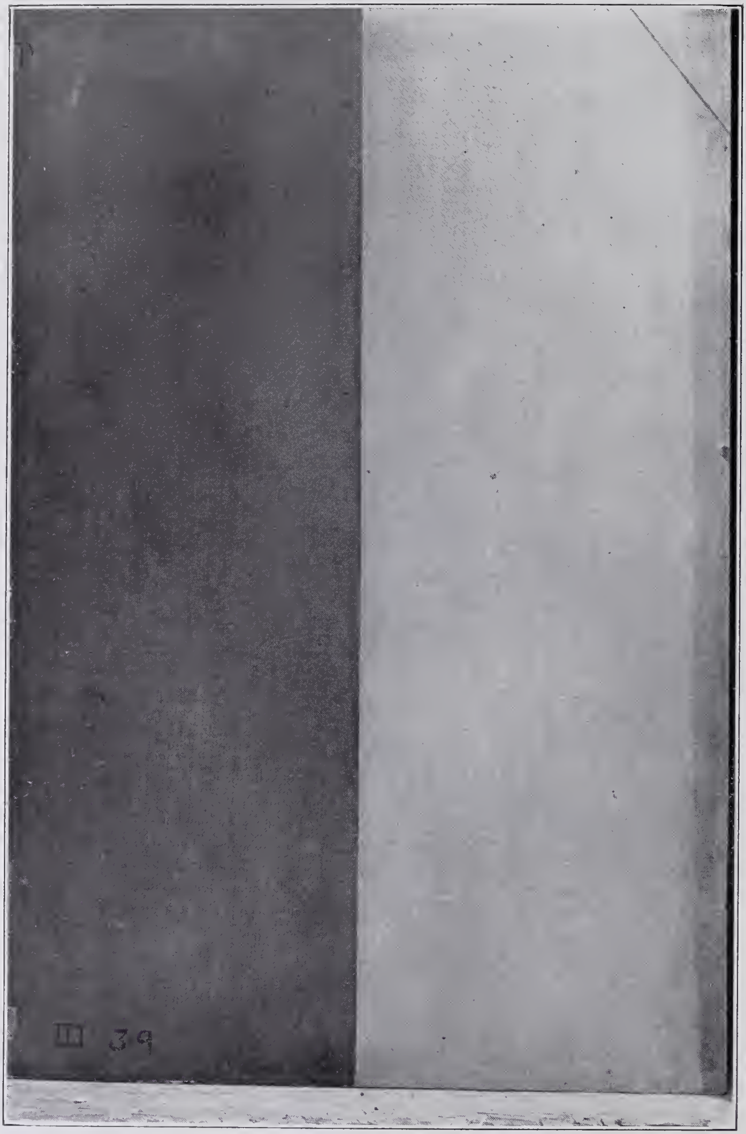
China Clay Asbestine Gypsum

Plate No. 41—Chrome Green.

This pigment, like Nos. 34 and 39, has proved itself to be a good inhibitor as well as a good excluder. Its color is permanent, its surface smooth, and its general appearance excellent from every standpoint considered.

Plate No. 44—Prussian Blue I.

Very glossy surface exhibited, resembling a varnish coating, even after 18 months' exposure, indicating that this pigment makes a perfect



Perfect Condition of Plate Painted with Zinc Chromate; One-Half Stripped

excluder. Its action in preventing rapid oxidation of linseed oil may account for its water-shedding value and suggests further experiments with the ferrocyanides.

Plate No. 45—Prussian Blue S.

Same as No. 44 thus far. Excluding properties account for its value.

Plate No. 48—Ultramarine Blue.

Early vehicle decay and excessive chalking. Checking and alligatoring deeply. Corrosion proceeding rapidly.

Plate No. 49—Zinc and Lead Chromate.

Excellent general condition throughout, with smooth surface and no corrosion. Stands in the inhibitive type of pigments.

Plate No. 51—Black Oxide of Iron.

Color good and general condition good so far.

Mixed Paints Nos. 111, 222, 333 and 444 (See Analysis on Chart) were in general good condition. The color of the green was too light, however.

Mixed paints Nos. 555, 666, 777 and 888 (See Analysis on Chart) were in general fair condition thus far.

Plates Nos. 2000, 3000 and 4000, coated first with Red Lead, Zinc Chromate and Lead Chromate respectively and then topped with one coat of Paint No. 4444, were all protected from corrosion. The outer coating of Paint No. 4444 had checked to a great extent in some cases and indicated that an excess of varnish had been used.

Paint No. 100 (See Analysis).

Condition of film good, but bad corrosion shown wherever metal is exposed. Pitting has forced paint off in places.

Paint No. 90 (See Analysis).

Same as No. 100.

Paint B 1000 (Chromium Resinate).

This vehicle soluble material gives good results when used in small percentage as a medicative in a paint intended to be inhibitive throughout.

Paint No. 5555 (Coal Tar).

This paint was applied on one panel prime-coated with red lead. Deep alligatoring ensued, exposing the red lead. The same paint was also applied direct to a steel panel and the same broad alligatoring appeared early after exposure. Action of the sun probably responsible for this effect.

Special H. G. Formulas, Nos. 1111, 2222, 3333.

In general excellent condition throughout (See Analysis on Chart).

CONCLUSION.

In summing up these results, it is evident that the use of a small percentage of the high-power inhibitive type of pigments (zinc chromate, basic chromate of lead, prussian blue, zinc and barium chromate, zinc and lead chromate, chrome green, etc.), admixed with some of the neutral and inert pigments (zinc oxide, sublimed leads, red lead, silica, asbestine, china clay, iron oxides, etc.) would give the most efficient protection to steel and iron. For further details, the reader is referred to a consideration of the formulas given in the appendix to this bulletin, or to those formulas proposed in Chapters IX and X of "Corrosion and Preservation of Iron and Steel," by Cushman and Gardner.*

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* Published by McGraw-Hill Book Co., New York.

APPENDIX

Although in the First Report on the Steel Test Fences, published by the Scientific Section in the fall of 1908, the painting of the steel plates was described in a general way, the detail of the work was not given. The purpose of this appendix is to present a report on the application of each paint, so that a complete record will be on file for the use of members of the Association, who may wish to make an inspection of the tests.

There were three principal grades of metal used in the test, and the analyses of these metals, together with the analyses of the special metals tested, will be found in the chart facing the front of this report.

The steel plates were all of one standard size, 24 in. wide, 36 in. high and ⅛ in. in thickness. One-half the number of plates were pickled in sulphuric acid, washed in water, and later in a 10% solution of caustic soda. The plates were again washed in water and then wiped dry. Upon the pickled plates the paints were applied with a definite spreading rate of 900 sq. feet per gallon, while the unpickled plates, which were coated with ordinary mill scale, were painted without any spreading rate, so as to more closely duplicate the ordinary method of painting structural steel.

The design of the fence itself, upon which the plates were erected, is apparent from observation of the illustration on page 2. The plates were erected after painting indoors, and insulated to prevent any galvanic contact, with rubber covered buttons. The usual method for conducting painting tests was followed, each paint being applied with a clean brush and in the presence of the various inspectors. Three coats were applied, and a period of one week elapsed between the drying of each coat. The working properties and appearance of each plate during and after the painting was noted, and this information was recorded in the detailed report, which follows.

The plates pickled in sulphuric acid were used throughout on the pigments numbered from 1 to 51, and a definite spreading rate of 900

sq. ft. per gallon was adopted for this set of tests. For the special formulas two sets of plates were used; one set of cleaned plates painted with the definite spreading rate of 900 sq. ft., and one set of plates containing the black mill scale, painted without any spreading rate. In nearly ever case the paints were placed on six plates of the three standard grades of steel and exposed on either side of the three fences, so as to get information as to whether the quality of the steel had anything to do wtih the wearing properties of the paint.

It will be noticed in making an inspection of the plates that each plate has at the lower left-hand corner two numbers. The Roman numerals stand for the grade of steel used in the test, and the Arabic figures indicate the formula numbers. In the detailed report which follows, T stands for temperature (Fahrenheit), B stands for barometer and W stands for weather.

HENRY A. GARDNER,
Director of Tests.

DETAILED REPORT OF PAINT TESTS

SINGLE PIGMENT TESTS

No. 1 Dutch Process White Lead.

Sp. Gr. of Pigment			6.83	
Lbs. to Gallon Oil			20.49	
Sp. Gr. of Paint as received			2.45	
Wt. of Paint per Gallon			20.4	
Grams to Panel			61	
Condition of Paint			Good	
Working Properties			Good—Brushes smooth	
Drying			24 hours all coats	
1 Coat	Oct. 26, '08	T 60	B 29.94	W clear
2 Coat	Nov. 3	T 53	B 30.23	W clear
3 Coat	Nov. 7	T 48	B 29.66	W cloudy

No. 2 Quick Process White Lead.

Sp. Gr. of Pigment			6.78	
Lbs. to Gallon Oil			20.34	
Sp. Gr. of Paint as received			2.47	
Wt. of Paint per Gallon			20.56	
Grams to Panel			62	
Condition of Paint			Good	
Working Properties			Works easy	
Drying			24 hours all coats	
1 Coat	Oct. 26	T 60	B 29.94	W fair
2 Coat	Nov. 3	T 54	B 30.23	W clear
3 Coat	Nov. 7	T 52	B 29.66	W cloudy

No. 3 Zinc Oxide.

Sp. Gr. of Pigment			5.56
Lbs. to Gallon Oil			16.68
Sp. Gr. of Paint as received			2.12
Wt. of Paint per Gallon			17.68
Grams to Panel			50.5 plus 8.5—59
Condition			Very thick paste requiring 170 gm. turpentine to thin 1000 gms. to working consistency, thus raising the amount per panel to 59 gms.
Working Properties			Smooth and easy without brush marks.
Drying			Not as good as No. 1 and No. 2. Required 36 hours to set.
1 Coat	Oct. 26	T 60	B 29.94 W fair
2 Coat	Nov. 4	T 60	B 29.61 W clear
3 Coat	Nov. 7	T 55	B 29.66 W cloudy

No. 4 Sublimed White Lead.

Sp. Gr. of Pigment			6.45
Lbs. to Gallon Oil			19.17
Sp. Gr. of Paint as received			2.36
Wt. of Paint per Gallon			19.65
Grams to Panel			59
Condition of Paint			Good
Working Properties			Heavy
Drying			Good
1 Coat	Oct. 27	T 60	B 29.98 W fair
2 Coat	Nov. 4	T 60	B 29.61 W clear
3 Coat	Nov. 7	T 56	B 29.66 W cloudy

No. 5 Sublimed Blue Lead.

Sp. Gr. of Pigment			6.39
Lbs. to Gallon Oil			19.17
Sp. Gr. of Paint as received			2.42
Wt. of Paint per Gallon			20.1
Grams to Panel			61
Condition of Paint			Good
Working Properties			Somewhat heavy. Better than No. 4.
Drying			Good
1 Coat	Oct. 27	T 58	B 29.98 W fair
2 Coat	Nov. 4	T 60	B 29.61 W clear
3 Coat	Nov. 9	T 52	B 29.91 W clear

No. 6 Lithopone.

Sp. Gr. of Pigment			4.26		
Lbs. to Gallon Oil			12.78		
Sp. Gr. of Paint as received			1.80		
Wt. of Paint per Gallon			15		
Grams to Panel			45.3		
Condition of Paint			Good		
Working Properties			Fine. No brush marks		
Drying			Not very good. Tacky after 40 hours. Better on second and third coats		
1 Coat	Oct. 27	T 58	B 29.98	W clear	
2 Coat	Nov. 4	T 60	B 29.61	W cloudy	
3 Coat	Nov. 9	T 55	B 29.91	W clear	

No. 7 Zinc Lead White.

Sp. Gr. of Pigment			4.42	
Lbs. to Gallon Oil			13.26	
Sp. Gr. of Paint as received			1.96	
Wt. of Paint per Gallon			16.37	
Grams to Panel			49.4	
Condition of Paint			Good	
Working Properties			Good	
Drying			Good	
1 Coat	Oct. 27	T 58	B 29.98	W cloudy
2 Coat	Nov. 4	T 60	B 29.61	W cloudy
3 Coat	Nov. 9	T 56	B 29.91	W clear

No. 9 Orange Mineral American.

Sp. Gr. of Pigment			8.97	
Lbs. to Gallon Oil			26.91	
Sp. Gr. of Paint as received			2.97	
Wt. of Paint per Gallon			24.74	
Grams to Panel			74.7	
Condition of Paint			Good	
Working Properties			Smooth—no brush marks	
Drying			Good	
1 Coat	Oct. 28	T 58	B 30.01	W cloudy
2 Coat	Nov. 4	T 65	B 29.61	W cloudy
3 Coat	Nov. 9	T 58	B 29.91	W clear

No. 10 Red Lead.

Sp. Gr. of Pigment			8.70	
Lbs. to Gallon Oil			26.10	
Sp. Gr. of Paint as received			2.93	
Wt. of Paint per Gallon			24.4	
Grams to Panel			73.6	
Condition of Paint			Settled but in fair condition	
Working Properties			Smooth—no brush marks	
Drying			Good	
1 Coat	Oct. 28	T 58	B 30.01	W cloudy
2 Coat	Nov. 4	T 65	B 29.61	W cloudy
3 Coat	Nov. 9	T 64	B 29.91	W clear

No. 12 Bright Red Oxide (62a).

Sp. Gr. of Pigment			5.26	
Pigment to Gallon Oil			15.78	
Sp. Gr. of Paint as received			2.05	
Wt. of Gallon Paint			17.07	
Grams to Panel			51.5 plus 8.3—60	
Condition			Thick paste requiring 166 gm. turps to 1000 gm. paint to make a paint of spreading consistency—thus raising the gms. per panel to 60	
Working Properties			Flows on panel	
Drying			Slow drier	
1 Coat	Oct. 28	T 58	B 30.01	W cloudy
2 Coat	Nov. 4	T 65	B 29.61	W cloudy
3 Coat	Nov. 9	T 66	B 29.91	W clear

No. 14 Venetian Red.

Sp. Gr. of Pigment			3.1	
Pigment to Gal. Oil			9.30	
Sp. Gr. of Paint as received			1.52	
Wt. of Gallon Paint			12.6	
Grams to Panel			38	
Condition			Good smooth paint	
Working Properties			Smooth. No brush marks	
Drying			Good on all coats	
1 Coat	Oct. 29	T 56	B 29.82	W cloudy
2 Coat	Nov. 4	T 65	B 29.61	W cloudy
3 Coat	Nov. 9	T 65	B 29.91	W clear

No. 15 Prince's Metallic Brown.

Sp. Gr. of Pigment		3.17		
Lbs. to Gallon Oil		9.51		
Sp. Gr. Paint as received		1.5		
Wt. of Gallon Paint		12.49		
Grams to Panel		37.7		
Condition		Good		
Working Properties		Works stiff—some brush marks		
Drying		Fair on all coats		
1 Coat Oct. 29	T 56	B 29.82	W cloudy	
2 Coat Nov. 5	T 64	B 29.92	W cloudy	
3 Coat Nov. 9	T 64	B 29.91	W clear	

No. 16 Natural Graphite.

Sp. Gr. of Pigment		2.60		
Lbs. to Gallon Oil		7.80		
Sp. Gr. of Paint as received		1.37		
Wt. to Gallon Paint		11.4		
Grams to Panel		34.4		
Condition		Good		
Working Properties		Brushes heavy		
Drying		Very slow. Tacky after three days. Dry in seven days		
1 Coat Oct. 29	T 56	B 29.82	W cloudy	
2 Coat Nov. 5	T 50	B 29.92	W cloudy	
3 Coat Nov. 9	T 62	B 29.91	W cloudy	

No. 17 Acheson Graphite.

Sp. Gr. of Pigment		2.21		
Lbs. to Gallon Oil		6.63		
Sp. Gr. of Paint as received		1.22		
Wt. per Gallon Paint		10.2		
Grams to Panel		30.8		
Condition		Thick		
Working Properties		Heavy		
Drying		Slow all through		
1 Coat Oct. 29	T 56	B 29.82	W cloudy	
2 Coat Nov. 5	T 50	B 29.92	W cloudy	
3 Coat Nov. 9	T 62	B 29.91	W cloudy	

No. 19 Lamp Black.

Sp. Gr. of Pigment			1.82	
Lbs. to Gallon Oil			L. B. 1.82 Barytes 8.92	
Sp. Gr. of Paint as received			1.60	
Wt. per Gallon Paint			13.32	
Grams to Panel			40.2	
Condition			Good	
Working Properties			Works fair	
Drying			Slow. Tacky after three days	
1 Coat	Oct. 29	T 56	B 29.82	W cloudy
2 Coat	Nov. 5	T 54	B 29.92	W clear
3 Coat	Nov. 10	T 60	B 30.02	W clear

No. 20 Willow Charcoal.

Sp. Gr. of Pigment			1.49	
Lbs. to Gallon Oil			4.47	
Sp. Gr. of Paint as received			1.08	
Wt. per Gallon Paint			8.99	
Grams to Panel			27	
Condition			Good	
Working Properties			Somewhat stiff	
Drying			Slow drier. Tacky for three or four days	
1 Coat	Oct. 29	T 56	B 29.82	W cloudy
2 Coat	Nov. 5	T 65	B 29.92	W clear
3 Coat		T	B	W

No. 21 Gas Carbon Black.

Sp. Gr. of Pigment			1.85	
Lbs. to Gallon Oil			C. B. 1.39 Barytes 10.03	
Sp. Gr. of Paint as received			1.67	
Wt. per Gallon Paint			13.94	
Grams to Panel			42 plus 8.72—50.7	
Condition			Thick paste; required 218 gms. Turps to 1000 gms. paste	
Working Properties			Fair	
Drying			Very slow. Tacky and fatty after three days	
1 Coat	Oct. 30	T 56	B 29.64	W clear
2 Coat	Nov. 5	T 54	B 29.92	W clear
3 Coat	Nov. 10	T 60	B 30.02	W clear

No. 24 French Yellow Ochre.

Sp. Gr. of Pigment			2.94		
Lbs. to Gallon Oil			8.82		
Sp. Gr. of Paint as received			1.46		
Wt. of Paint per Gallon			12.16		
Grams to Panel			37		
Condition of Paint			Good		
Working Properties			Stiff		
Drying			Slow all coats		
1 Coat	Oct. 30	T 56	B 29.64	W	clear
2 Coat	Nov. 5	T 50	B 29.92	W	cloudy
3 Coat	Nov. 10	T 60	B 30.02	W	clear

No. 27 Barytes Natural.

Sp. Gr. of Pigment			4.46		
Lbs. to Gallon Oil			13.38		
Sp. Gr. of Paint as received			1.83		
Wt. of Paint per Gallon			15.24		
Grams to Panel			46		
Condition			Settled in can		
Working			Brushes easy		
Drying			Slow		
1 Coat	Oct. 30	T 54	B 29.64	W	fair
2 Coat	Nov. 5	T 50	B 29.92	W	cloudy
3 Coat	Nov. 10	T 60	B 30.02	W	clear

No. 28 Barytes Precipitated.

Sp. Gr. of Pigment			4.23		
Lbs. to Gallon Oil			12.69		
Sp. Gr. of Paint as received			1.84		
Wt. of Paint per Gallon			15.32		
Grams to Panel			46		
Condition			Good		
Working Properties			Brushes stiff. Leaves marks		
Drying			Slow		
1 Coat	Oct. 30	T 54	B 29.64	W	fair
2 Coat	Nov. 5	T 48	B 29.92	W	cloudy
3 Coat	Nov. 10	T 64	B 30.02	W	clear

No. 29 Calc. Carb. (Whiting).

Sp. Gr. of Pigment			5.48	
Lbs. to Gallon Oil			8.22	
Sp. Gr. of Paint as received			1.37	
Wt. of Gallon Paint			11.41	
Grams to Panel			34.5	
Condition			Good	
Working Properties			Brushes stiff	
Drying			Slow	
1 Coat	Oct. 30	T 54	B 29.64	W fair
2 Coat	Nov. 5	T 44	B 29.92	W cloudy
3 Coat	Nov. 10	T 64	B 30.02	W clear

No. 30 Calc. Carb. (Precip.)

Sp. Gr. of Pigment			2.56	
Lbs. to Gallon Oil			7.68	
Sp. Gr. of Paint as received			1.35	
Wt. of Gallon Paint			11.24	
Grams per Panel			34	
Condition			Good	
Working Properties			Brushes stiff	
Drying			Slow. Tacky—fatty	
1 Coat	Oct. 30	T 52	B 29.64	W fair
2 Coat	Nov. 6	T 28	B 30.03	W clear
3 Coat	Nov. 10	T 64	B 30.02	W clear

No. 31 Calcium Sulphate (Gypsum).

Sp. Gr. of Pigment			2.33	
Lbs. to Gallon Oil			6.99	
Sp. Gr. of Paint as received			1.25	
Wt. per Gallon Paint			10.41	
Grams to Panel			31.4	
Condition			Good	
Brushing Properties			Thin	
Drying			Slow, fatty	
1 Coat	Oct. 30	T 52	B 29.64	W fair
2 Coat	Nov. 6	T 32	B 30.03	W clear
3 Coat	Nov. 10	T 64	B 30.02	W clear

No. 32 China Clay (Kaolin).

Sp. Gr. of Pigment as received			2.67	
Lbs. to Gallon Oil			8.01	
Sp. Gr. of Paint as received			1.34	
Lbs. to Gallon Paint			11.19	
Grams to Panel			34	
Condition			Good	
Working Properties			Brushed stiff	
Drying			Slow and fatty. Wet after four days	
1 Coat	Oct. 30	T 52	B 29.64	W fair
2 Coat	Nov. 6	T 50	B 30.03	W clear
3 Coat	Nov. 10	T 65	B 30.02	W clear

No. 33 Asbestine (Silicate Magnesium).

Sp. Gr. of Pigment			2.75	
Lbs. to Gallon Oil			8.25	
Sp. Gr. of Paint as received			1.38	
Wt. of Gallon Paint			11.49	
Grams to Panel			34.7	
Condition			Good	
Working Properties			Brushed stiff	
Drying			Slow	
1 Coat	Oct. 30	T 54	B 29.64	W fair
2 Coat	Nov. 6	T 52	B 30.03	W clear
3 Coat	Nov. 10	T 67	B 30.02	W clear

No. 34 American Vermilion (Chrome Scarlet).

Sp. Gr. of Pigment			6.83	
Lbs. to Gallon Oil			20.49	
Sp. Gr. of Paint as received				
Wt. of Gallon Paint			21.36	
Grams to Panel			64.5	
Condition			Thick and settled	
Working Properties			Brushes free and easy	
Drying			Good on all coats	
1 Coat	Oct. 31	T 54	B 30.15	W fair
2 Coat	Nov. 6	T 34	B 30.03	W clear
3 Coat	Nov. 10	T 65	B 30.02	W clear

No. 36 Med. Chrome Yellow.

Sp. Gr. of Pigment			5.88	
Lbs. to Gallon Oil			17.64	
Sp. Gr. of Paint as received				
Wt. of Gallon Paint			18.8	
Grams to Panel			56 plus 11.1=67.1	
Condition			Thick paste. 1500 gms. require 299 gms. Turps	
Working Properties			Brushes smooth and easy	
Drying			Good on all coats.	
1 Coat	Oct. 31	T 58	B 30.15	W fair
2 Coat	Nov. 6	T 36	B 30.03	W clear
3 Coat	Nov. 11	T 50	B 30.01	W cloudy

No. 39 Zinc Chromate.

Sp. Gr. of Pigment			3.57	
Lbs. to Gallon Oil			10.71	
Sp. Gr. of Paint as received			1.57	
Wt. of Paint per Gallon			13.07	
Grams to Panel			39.2	
Condition			Good	
Working Properties			Brushes stiff and hard	
Drying			Very slow, not set after a week. Required 1 per cent. drier to set	
1 Coat	Oct. 31	T 58	B 30.15	W fair
2 Coat	Nov. 6	T 52	B 30.03	W clear
3 Coat	Nov. 11	T 50	B 30.01	W cloudy

No. 40 Zinc and Barium Chromate.

Sp. Gr. of Pigment			3.45	
Lbs. to Gallon Oil			10.35	
Sp. Gr. of Paint as received			1.58	
Wt. of Paint per Gallon			13.16	
Grams to Panel			40	
Condition			Good	
Working Properties			Brushes very hard	
Drying			Very slow. Fatty after six days. Required 1 per cent. drier to set	
1 Coat	Oct. 31	T 60	B 30.15	W fair
2 Coat	Nov. 6	T 52	B 30.03	W clear
3 Coat	Nov. 11	T 52	B 30.01	W cloudy

No. 41 Chrome Green (Blue Tone).

Sp. Gr. of Pigment			4.44		
Lbs. to Gallon Oil			13.32		
Sp. Gr. of Paint as received			1.94		
Wt. of Gallon Paint			16.16		
Grams to Panel			49		
Condition			Good		
Working Properties			Brushes very hard		
Drying			Slow on all coats		
1 Coat	Nov. 1	T 60	B 30.35	W fair	
2 Coat	Nov. 6	T 40	B 30.03	W clear	
3 Coat	Nov. 11	T 53	B 30.01	W cloudy	

No. 44 Prussian Blue (Stimulative).

Sp. Gr. of Pigment			1.96		
Lbs. to Gallon Oil			5.88		
Sp. Gr. of Paint as received					
Wt. per Gallon			9.95		
Grams to Panel			30		
Condition			Thick paste		
Working Properties			Works very hard. Leaves brush marks		
Drying			Good on all coats		
1 Coat	Nov. 1	T 60	B 30.35	W fair	
2 Coat	Nov. 6	T 42	B 30.03	W clear	
3 Coat	Nov. 11	T 54	B 30.01	W cloudy	
Sp. Gr. of Pigment			1.93		

No. 45 Inhibitive Prussian Blue.

Lbs. to Gallon Oil			5.79		
Sp. Gr. of Paint as received					
Wt. per Gallon			9.76		
Grams to Panel			29.5 plus 5—34.5		
Condition			Lumpy paste		
Working Properties			Works very hard. Left brush marks. Required 163 gms. turps to thin to working consistency		
Drying			Good		
1 Coat	Nov. 1	T 60	B 30.35	W fair	
2 Coat	Nov. 6	T 42	B 30.03	W clear	
3 Coat	Nov. 11	T 54	B 30.01	W cloudy	

No. 48 Ultramarine Blue.

Sp. Gr. of Pigment			2.40	
Lbs. of Gallon Oil			7.20	
Sp. Gr. of Paint as received			1.29	
Wt. per Gallon			10.74	
Grams to Panel			32.5	
Condition			Good	
Working Properties			Good	
Drying			Slow	
1 Coat	Nov. 1	T 60	B 30.35	W fair
2 Coat	Nov. 6	T 44	B 30.03	W clear
3 Coat	Nov. 11	T 60	B 30.01	W cloudy

No. 49 Zinc and Lead Chromate.

Sp. Gr. of Pigment			4.76	
Lbs. to Gallon Oil			14.28	
Sp. Gr. of Paint as received			1.92	
Wt. per Gallon			15.99	
Grams to Panel			48.3	
Condition			Thick	
Working Properties			Good	
Drying			Slow	
1 Coat	Nov. 1	T 60	B 30.35	W fair
2 Coat	Nov. 7	T 55	B 29.66	W clear
3 Coat	Nov. 11	T 60	B 30.01	W cloudy

No. 51 Magnetic Black Oxide.

Sp. Gr. of Pigment				
Lbs. to Gallon Oil			15	
Sp. Gr. of Paint as received			1.92	
Wt. per Gallon			15.99	
Grams to Panel			48.3	
Condition			Good	
Working Properties			Good	
Drying			Slow on all coats	
1 Coat	Nov. 1	T 61	B 30.35	W clear
2 Coat	Nov. 7	T 44	B 29.66	W clear
3 Coat	Nov. 11	T 60	B 30.01	W cloudy

SPECIAL MIXED PIGMENT TESTS

No. 90 Straight Lamp Black Paint With Turps and Drier.

Sp. Gr.			.962	
Lbs. per Gallon			8.01	
Grams to Plate			24	
Condition			Good	
Working			Good	
Drying			Good	
1 Coat	Nov. 1	T 60	B 30.35	W clear
2 Coat	Nov. 5	T 54	B 29.92	W clear

Two plates were used:
No. II Steel Black No. 90 B
No. II Steel Clean No. 90 C
Two coats were applied.
Formula:

Lamp Black	11.11
Japan	8.22
Boiled Oil	30.67
Raw Oil	50.00

No. 100 Straight Carbon Black Paint With Turps and Drier.

Sp. Gr.			.888	
Lbs. to Gallon			7.39	
Grams to Panel			22	
Condition			Good	
Working			Good	
Drying			Good	
1 Coat	Nov. 1	T 60	B 30.35	W clear
2 Coat	Nov. 5	T 54	B 29.92	W clear

Two plates used:
No. II Steel Black No. 100 B
No. II Steel Clean No. 100 C.
Two coats applied.
Formula:

Carbon Black	8.33
Japan	7.85
Raw Oil	82.35

No. 1000 Chrome Resinate in Oil.

Formula:

Chrome Resinate	40 per cent.
Raw Oil	60 per cent.

On black plate No. II metal No. 1000 B

Two coats applied.

1 Coat	Nov. 2	T 60	B 30.42	W clear
2 Coat	Nov. 7	T 55	B 29.66	W clear

Also applied to clean plate No. II metal, one coat, No. 1000 C.

Top coat consisted of
55 per cent. Indian Red
15 per cent. Zinc Yellow
30 per cent. Chrome Resinate

1 Plate No. 1000 X, 2 coats above formula.

No. 2000. This test consists of 6 steel plates as follows:

No. I Metal Black
No. I Metal Clean
No. II Metal Black
No. II Metal Clean
No. III Metal Black
No. III Metal Clean

Each coated with zinc chromate No. 39 pigment, the clean metal with definite spreading rate and the black metal without.

1 coat Nov. 3. They were topped with 1 coat of excluding paint No. 4444.

2 coat Nov. 8. The clean plates with spreading rate and the black plates without.

No. 3000. This test consists of 6 plates as follows:

No. I Metal Black
No. I Metal Clean
No. II Metal Black
No. II Metal Clean
No. III Metal Black
No. III Metal Clean

each first coated with lead chromate.

1 coat No. 36 Pigment on 11-3-08.

2 coat. Then topped on 11-8-08 with a coat of excluding paint No. 4444.

The clean plates were painted with a definite spreading rate and the black plates without.

No. 4000. This test consists of 6 plates as follows:

No. I Metal Black
No. I Metal Clean
No. II Metal Black
No. II Metal Clean
No. III Metal Black
No. III Metal Clean

each first coated with Red Lead.

1 Coat No. 10 Pigment on 11-3-08.

2 Coat. Then topped with a coat of Excluder No. 4444 on 11-8-08.

The clean plates were painted with a definite spreading rate and the black plates without.

MIXED PAINTS

No. 111 Brown.

This test made on:

No. I Metal Black	Sp. Gr. of Paint as received	1.30
No. I Metal Clean	Lbs. to Gallon	10.82
No. II Metal Black	Grams to Panel	32.7
No. II Metal Clean	Condition	Good
No. III Metal Black	Working	Good
No. III Metal Clean	Drying	Good
Pigment formula:		Paint formula:
60	Burnt Umber	22.50
20	Zn & Ba Chromate	7.50
20	Zinc Lead	7.50
	Japan	3.40
	Raw Oil	59.10

1 Coat	Nov. 1	T 58	B 30.35	W fair
2 Coat	Nov. 7	T 44	B 29.66	W fair
3 Coat	Nov. 12	T 60	B 30.14	W clear

Applied on Black Steel without spreading rate.
Applied on Clean Steel with spreading rate.

No. 222 Black.

This test on:

No. I Metal Black	Sp. Gr. of Paint as received	1.30
No. I Metal Clean	Lbs. to Gallon	10.86
No. II Metal Black	Grams to Panel	32.8
No. II Metal Clean	Condition	Good
No. III Metal Black	Working	Good
No. III Metal Clean	Drying	Good
Pigment formula:		Paint formula:
30	Bone Black	13.72
2	Prussian Blue	.92
10	XX Zinc	4.57
50	Silex	22.86
8	$CaCO_3$	3.66
	Japan	8.33
	Raw Oil	45.94

1 Coat	Nov. 1	T 58	B 30.35	W fair
2 Coat	Nov. 7	T 44	B 29.66	W clear
3 Coat	Nov. 12	T 60	B 30.14	W fair

Applied with spreading rate on clean metal.
Applied without spreading rate on black metal.

No. 333 White.

This test made on:

No. I Metal Clean		Sp. Gr. of Paint as received	1.744
No. I Metal Black		Lbs. to Gallon	14.52
No. II Metal Clean		Grams to Panel	43.8
No. II Metal Black		Condition	Good
No. III Metal Clean		Working	Good
No. III Metal Black		Drying	Good

Pigment formula:	Paint formula:	
35	Zinc Oxide	20.90
45	Zinc Lead	26.87
5	$CaCO_3$	2.98
15	Silex	8.95
	Japan	1.56
	Raw Oil	38.74

1 Coat	Nov. 1	T 58	B 30.35	W fair
2 Coat	Nov. 7	T 44	B 29.66	W clear
3 Coat	Nov. 12	T 60	B 30.14	W fair

Applied with spreading rate on clean metal.
Applied without spreading rate on black metal.

No. 444 Green.

This test made on:

No. I Metal Clean		Sp. Gr. of Paint as received	1.53
No. I Metal Black		Lbs. to Gallon	12.77
No. II Metal Clean		Grams to Panel	38.6
No. II Metal Black		Condition	Good
No. III Metal Clean		Working	Good
No. III Metal Black		Drying	Good

Pigment formula:	Paint formula:	
60	XX Zinc	32.47
15	Zinc Chromate	8.30
3	Prussian Blue I	1.44
2	Calcium Carbonate	1.08
20	Silex	10.83
	Japan	2.22
	Raw Oil	43.66

1 Coat	Nov. 2	T 58	B 30.42	W fair
2 Coat	Nov. 7	T 38	B 29.66	W cloudy
3 Coat	Nov. 12	T 60	B 30.14	W fair

Applied with spreading rate on clean metal.
Applied without spreading rate on black metal.

No. 555 Black.

This test applied on:

No. I Metal Black		Sp. Gr. of Paint as received	1.125
No. I Metal Clean		Lbs. to Gallon	9.37
No. II Metal Black		Grams to Panel	28
No. II Metal Clean		Condition	Good
No. III Metal Black		Working	Good
No. III Metal Clean		Drying	Good

Pigment formula:		Paint formula:
40	Lamp Black	8.18
40	Nat. Graphite	8.18
20	Barytes	4.09
	Japan	8.33
	Raw Oil	71.22

1 Coat	Nov. 2	T 58	B 30.42	W	fair
2 Coat	Nov. 7	T 46	B 29.66	W	clear
3 Coat	Nov. 12	T 60	B 30.14	W	fair

Applied on clean plates with spreading rate.
Applied on black plates without spreading rate.

No. 666 Brown.

This test applied on:

No. I Metal Black		Sp. Gr. of Paint as received	1.41
No. I Metal Clean		Lbs. to Gallon	11.74
No. II Metal Black		Grams to Panel	35.5
No. II Metal Clean		Condition	Good
No. III Metal Black		Working	Good
No. III Metal Clean		Drying	Good

Pigment formula:		Paint formula:
50	Red Oxide 62a	22.94
5	Carbon Black	2.35
35	Barytes	15.30
10	Med. Chrome Yellow	5.88
	Japan	3.20
	Raw Oil	50.33

1 Coat	Nov. 2	T 58	B 30.42	W	fair
2 Coat	Nov. 7	T 44	B 29.66	W	clear
3 Coats	Nov. 12	T 60	B 30.14	W	fair

Applied on clean plates with spreading rate.
Applied on black plates without spreading rate.

No. 777 White.

This test made on:

No. I Metal Black		Sp. Gr. of Paint as received	1.75
No. I Metal Clean		Lbs. to Gallon	14.55
No. II Metal Black		Grams to Panel	44
No. II Metal Clean		Condition	Good
No. III Metal Black		Working	Good
No. III Metal Clean		Drying	Good

Pigment formula:		Paint formula:
60	Sublimed Lead	44.80
20	Blanc Fixe	7.46
20	Gypsum	7.46
	Japan	1.60
	Raw Oil	38.68

1 Coat	Nov. 2	T 58	B 30.42	W clear
2 Coat	Nov. 7	T 44	B 29 66	W clear
3 Coat	Nov. 12	T 60	B 30.14	W fair

Applied on clean metal with spreading rate.

Applied on black metal without spreading rate.

No. 888 Green.

This test made on:

No. I Metal Black		Sp. Gr. of Paint as received	1.75
No. I Metal Clean		Lbs. to Gallon	14.57
No. II Metal Black		Grams to Panel	44
No. II Metal Clean		Condition	Good
No. III Metal Black		Working	Good
No. III Metal Clean		Drying	Good

Pigment formula:		Paint formula:
5	Chinese Blue S	4.32
35	Lemon Chrome Yellow	18.94
20	White Lead	16.23
40	Barytes	21.35
	Japan	2.35
	Raw Oil	38.51

1 Coat	Nov. 2	T 58	B 30.42	W clear
2 Coat	Nov. 7	T 44	B 29.66	W clear
3 Coat	Nov. 12	T 60	B 30.14	W fair

Applied on clean metal with spreading rate.

Applied on black metal without spreading rate.

SPECIAL H. G. FORMULAS

No. 1111 Green.

Two coats applied on four plates without spreading rate.
Test made on:

No. I Metal Black
No. IV Metal Black
No. V Metal Black
No. III Metal Clean

Pigment formula:	Paint formula:	
51.87	Zinc Oxide (ZnO)	24.93
21.76	Floated Silex (SiO_2)	10.46
7.80	Zinc Yellow (Zinc Chrom'te)	3.75
8.17	Med. Chro. Yellow (Lead ")	3.93
6.07	Prussian Blue	2.92
4.33	Paris White $CaCO_3$	2.08
	Turps Japan Drier	3.50
	Raw Linseed Oil	48.43

1 Coat	Nov. 2	T 58	B 30.42	W clear
2 Coat	Nov. 8	T 65	B 29.63	W clear

Plate No. 4 Virginia Iron used.

No. 2222 Red.

Two coats applied on four plates without spreading rate.
Test made on:

No. I Black Metal
No. IV Black Metal
No. V Black Metal
No. III Clean Metal

Pigment formula:	Paint formula:	
50.00	Red Oxide of Iron (Fe_2O_3)	.26.67
15.63	Zinc Yellow (Zinc Chro'ate)	8.33
3.75	Paris White ($CaCO_3$)	1.67
30.62	Floated Silex (SiO_2)	16.66
	Turps Japan Drier	4.54
	Raw Linseed Oil	42.13

1 Coat	Nov. 2	T 58	B 30.42	W clear
2 Coat	Nov. 8	T 65	B 29.63	W clear

Plate No. 3 Virginia Iron used.

No. 3333 Black.

Two coats applied on four plates without spreading rate.

Test made on:

No. I Black Metal
No. IV Black Metal
No. V Black Metal
No. III Clean Metal

Pigment formula:	Paint formula:	
30.00	Hydro Gas Carbon Black	6.65
10.00	Zinc Yellow (Zinc Chro'ate)	2.22
30.00	Zinc Oxide (ZnO)	6.65
30.00	Floated Silex (SiO_2)	6.65
	Turps Japan Drier	9.41
	Raw Linseed Oil	68.42

1 Coat	Nov. 2	T 58	B 30.42	W clear
2 Coat	Nov. 8	T 65	B 29.63	W clear

No. 4444 A. Excluder Paint.

Two coats applied without spreading rate.

Test made on:

No. II Metal Black
No. II Metal Clean

Sp. Gr. of Paint as received 1.275
Lbs. to Gallon 10.62

1 Coat	Nov. 3	T 60	B 30.23	W clear
2 Coat	Nov. 8	T 65	B 29.63	W clear

No. 5555 Special Paint (Coal Tar).

On two plates, two coats without spreading rate.

Test on:

No. II Steel Black
No. II Steel Clean

1 Coat	Nov. 3	T 60	B 30.23	W clear
2 Coat	Nov. 8	T 65	B 29.63	W clear

No. 6666 Special Graphite Paint.

(Silica 50 per cent.
(Graphite 50 per cent. } in Oil with Drier

Two coats without spreading rate on two plates.

Test made on:

No. II Metal Black
No. II Metal Clean

No. 7777 Special G. L. Paint.

One plate Clean No. 2 Metal.

No spreading rate.

Paint consists of special graphite and special refined oil.

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Rustless Coatings, Corrosion and Electrolysis of Iron and Steel — *M. P. Wood*
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The Microscope —*S. H. Gage*
The Theory and Practice of Enamelling on Iron and Steel —*Grünwald-Hodgson*
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Transactions of the American Electrochemical Society, 1909.

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- Corrosion of Fence Wire —*A. S. Cushman*
- The Analysis of Turpentine by Fractional Distillation with Steam —*Wm. C. Geer*
- The Corrosion of Iron —*A. S. Cushman*
- Some Technical Methods of Testing Miscellaneous Supplies —*P. H. Walker*

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- Drugs, Oils and Paints
- Journal of Industrial and Engineering Chemistry
- Journal of the American Chemical Society
- Journal of the Society of Chemical Industry
- Metallurgical and Chemical Engineering
- Oil, Paint and Drug Reporter
- The American Paint and Oil Dealer
- The Canadian Painter and Decorator
- The Decorator
- The Master Painters' Journal
- The Painters' Magazine

Publications of the Scientific Section

EDUCATIONAL BUREAU

PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

Bulletin Number

Preliminary Booklet—Addresses on Paint, Delivered Before the Michigan Chapter, American Institute of Architects, 1907. (*Out of print.*)

1—Tables of White Pigments and Vehicle—Standard Nomenclature.

2—Standard Can Sizes Recommended to Paint Manufacturers.

3—First Report on the Test Fences Erected by the Scientific Section. (*Out of print.*)

4—Methods for the Analysis of the Vehicle Constituents of Paint. (*Out of print.*)

5—Tests Upon the Corrosion of Iron to be Conducted by the Scientific Section. (*Out of print.*)

6—First Annual Report of the Scientific Section.

7—Preliminary Report on Steel Test Fences.

8—Report of Committee "E" on Preservative Coatings for Iron and Steel. (*Out of print.*)

9—Recent Technical Developments in Paint Manufacture.

10—Protective Coatings for Conservation of Structural Material.

11—The Corrosion of Iron and Steel. *By Alfred Sang.* (*Out of print.*)

12—The Function of Oxygen in the Corrosion of Metals. *By William H. Walker.*

Bulletin
Number

13—Protective Coatings for Steel and Iron. *By Robert S. Perry.* (*Out of print.*)

14—Coatings for the Conservation of Structural Material. (*Out of print.*)

15—Protective Coatings for Structural Material. *By R. S. Perry.*

16—First Annual Report on Wearing of Paints Applied to Atlantic City Test Fence.

17—First Annual Report on Wearing of Paints Applied to Pittsburg Test Fence.

18—First Annual Report on Atlantic City Steel Test Fence.

19—Laboratory Study of Panels on Atlantic City and Pittsburg Test Fences. (*Out of print.*)

20—Concrete Coatings. *By H. A. Gardner.*

21—A Brief Talk on Paints. *By Henry A. Gardner.* (*Out of print.*)

22—Annual Report for 1909.

Preliminary Bulletin—Second Edition—Physical Characteristics of a Paint Coating. *By R. S. Perry.*

23--The Theory of Driers, Etc.

24—Some Iron Oxides and Their Values.

25—Report on Examination of North Dakota Test Fences.

Special Bulletin—Scientifically Prepared Paints and Laws Governing Their Manufacture. *By Henry A. Gardner.*

An Exhibition of Certain Analogies Governing the Manufacture of Concrete and of Paint. *By R. S. Perry.*

26—Second Annual Report on Wearing of Paints Applied to Atlantic City Test Fence.

27—Second Annual Report on Atlantic City Steel Test Fence

28—Second Annual Report on Wearing of Paints Applied to Pittsburg Test Fence.

Bulletin No. 28

Second Annual Report

on Wearing of Paints Applied to Pittsburg Test Fence

INSPECTOR EXAMINING PITTSBURG TEST FENCE

SCIENTIFIC SECTION—EDUCATIONAL BUREAU

HENRY A. GARDNER, Director

PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

PHILADELPHIA, PA.

SECOND

ANNUAL REPORT

on

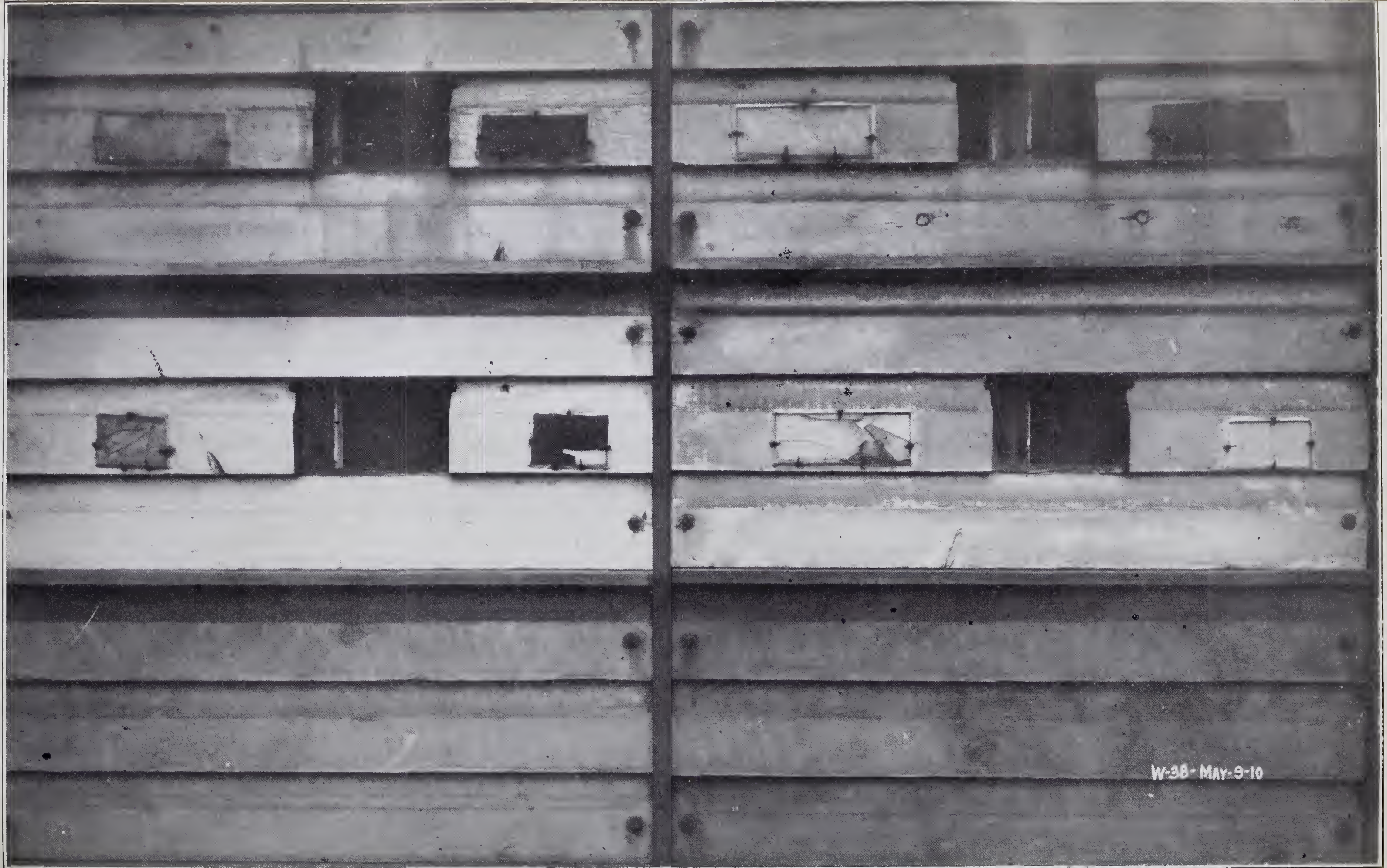
Wearing of Paints Applied

to

Pittsburg Test Fence

SCIENTIFIC SECTION—EDUCATIONAL BUREAU
HENRY A. GARDNER, Director

PAINT MANUFACTURERS' ASSOCIATION
OF THE UNITED STATES
Philadelphia, Pa.



Middle white panel is painted with a combination pigment formula | Middle white panel is painted with pure Corroded White Lead

NOTICE DIFFERENCE IN COLOR AFTER TWO YEARS' WEAR

PREFACE

Peculiar atmospheric conditions prevail in those large industrial centers, of which Pittsburg is a good example, that affect in a distinctive manner the life of structural materials. A study of the results of the paint tests at Pittsburg will afford the manufacturers and consumers of paint in these districts some information of interest.

HENRY A. GARDNER
Director

PITTSBURG TEST FENCE

EXPLANATORY NOTE ON THE INSPECTION

On Thursday, May 7th, the Second Annual Inspection of the Pittsburg Test Fence was made. The inspection party included those master painters representing the Pittsburg Master Painters' Association, who were in charge of the application of the paints in 1907, 1908 and 1909, together with the Test Fence Committee from the faculty of the Carnegie Technical Schools, and representatives of the Scientific Section.

Two of the members of the inspection party have been impressed with the lumber lottery existing in some field tests, which have been conducted, and feel that when the object of a test is to determine the relative value of paints, such tests should be conducted on a standard grade of wood, such as white pine. The use of cypress, pitch pine, and other faulty woods, is often the cause of the failure of a paint, which on good wood would show up well. For this reason, only the white pine panels painted with white paints were considered in the inspection, the yellow pine panels and cypress panels having been thrown out of the test at last year's inspection.

Checking, cracking and alligatoring on the painted surfaces were determined by using a magnifying glass. The degree of chalking existing was decided upon by using small pieces of black felt cloth, rubbing them against the surface of the panel; the degree of whiteness removed upon the cloth being indicative of the amount of chalking taking place. General condition was decided upon after carefully weighing the opinion of each member of the inspection party, as regards the general characteristics shown by each paint, such as checking, chalking, scaling, condition for repainting, hiding power, etc. The results have been charted and presented in this manner*

*An endeavor was made to use uniform terms in reporting on each formula. In some cases it was necessary to bring out more forcibly the condition by the insertion of qualifying remarks.

Whiteness of Sublimed White Lead | Darkness of Corroded White Lead

ON PITTSBURG TEST FENCE

Conclusions Reached from the Test.—The primary object of the test made at Pittsburg was to determine whether a combination paint, made of two or more pigments, would be equal or superior to single pigment paints. After one year's exposure, the combination type of paint proved more durable than the single pigment paints. These findings were confirmed at this year's inspection, when the roughened and blackened surfaces of the straight corroded white lead paints proved that they were unsatisfactory in or around Pittsburg. It is evidently necessary to combine with white lead some other pigment, such as zinc oxide, in order to get the best results.

It was early apparent that the combination type of paints, that is, those paints made of more than one pigment, indicated in most cases very excellent wear, with a minimum of blackness and a general good condition of surface.

Recommendation.—On account of the peculiar conditions which obtain in and around Pittsburg, as exemplified by these tests, the committee finds, as a result thereof, that the best white paint for general exterior use is made of white lead combined with zinc oxide and a moderate percentage of inert pigments, such as silica, asbestine or barytes.

Some Peculiar Conditions Affecting the Tests.—The inspectors were most impressed during the inspection by the blackness exhibited to such a high degree by certain panels, and the fair degree of whiteness by others. It is well known that in Pittsburg nearly all paints become darkened by the deposition on their surface of carbon particles emanating from the combustion of soft coal. Certain of the paints, however, presented fairly white surfaces, and it would thus appear that the extreme darkness shown by other paints was due to their composition. Corroded white lead when used alone was uniformly covered by black particles and the higher the percentage of corroded white lead in a paint the darker was the surface.. It was at first thought that this darkness was due to the softness of the white lead pigment or to its roughened surface in causing adherence of soot particles. Sublimed white lead, however, which is also a soft pigment, chalked even more progressively than corroded white lead, but

its surface was not rough and presented a very white appearance. Scrapings from the different panels are being taken, and after a careful analysis the findings from the investigations will be reported by a member of the Inspection Committee.

Alfred C. Rapp

Chairman Test Fence Committee, Pittsburg Branch,
Master Painters' Association

John Dewar

Member Fence Committee, Pittsburg Branch, Penna. State
Association of Master Painters

J. H. James.

Chairman Carnegie Technical Schools' Fence Committee

John A. Schaeffer

Instructor in Chemical Practice, Carnegie Technical Schools,
Pittsburg, Pa.

Henry A. Gardner

Director Scientific Section, Paint Mfrs. Asso. of U. S.

May 31, 1910

TESTS INAUGUR D IN 1907

CHART OF RESULTS OF INSPECTION OF TSBURG TEST FENCE, MAY, 1910

	FORMULAS				INERT PIGMENTS						REPORT OF INSPECTION				
Formula Number	Basic Carbonate White Lead	Zinc Oxide	Basic Sulphate White Lead	Zinc Lead White	Calcium Carbonate	Calcium Sulphate	Magnesium Silicate	Barium Sulphate	Silica	Blanc Fixe	CHALKING	CHECKING	GENERAL CONDITION	REMARKS	Panel Number
1	30	70									Slight	one	Good	Slight scaling; fairly white surface	2
2	50	50									Medium	ery slight	Fair	Panels quite dark and some scaling	4
3	20	50	20		10						Considerable	one	Good	Fairly white	6
4	48.5	48.5			3.0						Considerable	lateral and irregular	Fair	White surface	8
5	22	50			2		26				Medium	ery slight	Very good	Extremely white surface	10
		64						36			Very slight	ery bad, rough surface	Poor	Black surface.	12
7	37	63									Slight	light	Good	Medium white surface	14
	38	48							14		Slight	light	Good	White surface; slight scaling	16
9		73			2				25		None	eep; peeling in places	Very poor	Film brittle and surface dark	18
10	44	46			5		5				Medium	light lateral in places.	Good	Surface very white	20
11	50	50									Considerable	eep matt checking	Fair	Considerable scaling; formation of black coating shattered off	22
12	60	34				6% Inert Pigment					Medium	light	Fairly good	Surface white.	24
13		27	60		3		10				Medium	one	Excellent	Very white	26
14	25	25	20		5	25					Considerable	edium	Fair	Panel fairly white.	28
15	20	40		30	10						Slight	edium	Good	Surface quite dark	30
16	33	33						34			Medium	ery slight	Good	Quite white.	32
17	40	40					3	13		4	Considerable.	light, along lateral lines	Fair.	Surface fairly white.	34
18	75	25									Medium	light, with some scaling	Good	Surface has become quite dark	36
19		25	75								Considerable.	one	Excellent	No black coating; surface very white, due to inertness of pigment or progressive chalking	38
20	67.0	19.5			10.0		3.5				Medium	edium	Good		40
33	15	30	25						30		Heavy	one	Fair.	White surface.	168
34	38.95	33.58	4.81		19.48			1.59	1.59		Considerable.	ery slight	Good	Surface is very white; progressive chalking may have prevented formation of black coating	172
35	37.51	25.87	7.84		20.36			4.21	4.21		Bad	one	Good	Very white, no black coating evident	173
36	100										Bad	ad	Fair.	Surface is dead black; shattered in places	174
37	100										Extremely bad	edium	Fair.	Very black surface and mottled in places	175
38	100										Very bad and quite dust	ery bad, with scaling.	Poor	Black surface is loose and shattered	176
39				100							Considerable.	light	Good	Panel surface quite white	177
40			100								Very bad	light	Good	Surface very white, possibly due to progressive chalking or inertness of pigment.	178
45		90			10						Slight	onsiderable	Fair.	White surface	169
46		61						39			Slight	light	Fair.	Considerable scaling present; surface fairly white.	170
47		100									Bad	Bad	Bad.	Bad condition throughout	171

Inspection of 1907 Test Panels on Pittsburg Test Fence

Formula No. 1—Panel No. 2.

Basic Carbonate — White Lead	30%
Zinc Oxide	70%
	100%

Chalking: Slight.
Checking: None.
General Condition: Good.
Remarks: Slight scaling. Fairly white surface.

Formula No. 2—Panel No. 4.

Basic Carbonate — White Lead	50%
Zinc Oxide	50%
	100%

Chalking: Medium.
Checking: Very slight.
General Condition: Fair.
Remarks: Panel quite dark, and some scaling.

Formula No. 3—Panel No. 6.

Basic Carbonate — White Lead	20%
Basic Sulphate—White Lead	20%
Zinc Oxide	50%
Calcium Carbonate	10%
	100%

Chalking: Considerable.
Checking: None.
General Condition: Good
Remarks: Fairly white.

Formula No. 4—Panel No. 8.

Basic Carbonate — White Lead	48.5%
Zinc Oxide	48.5%
Calcium Carbonate	3.0%
	100.0%

Chalking: Considerable.
Checking: Lateral and irregular.
General Condition: Fair.
Remarks: White surface.

Formula No. 5—Panel No. 10.

Basic Carbonate — White Lead	22%	Chalking: Medium.
Zinc Oxide	50%	Checking: Very slight.
Calcium Carbonate	2%	General Condition: Very good.
Aluminum Silicate and Asbestine	26%	Remarks: Extremely white surface.
	100%	

Formula No. 6—Panel No. 12.

Zinc Oxide	64%	Chalking: Very slight.
Barytes	36%	Checking: Very bad, with rough surface.
	100%	General Condition: Poor.
		Remarks: Black surface.

Formula No. 7—Panel No. 14.

Basic Carbonate — White Lead	37%	Chalking: Slight.
Zinc Oxide	63%	Checking: Slight.
	100%	General Condition: Good.
		Remarks: Medium white surface.

Formula No. 8—Panel No. 16.

Basic Carbonate — White Lead	38%	Chalking: Slight.
Zinc Oxide	48%	Checking: Slight.
Silica	14%	General Condition: Good.
	100%	Remarks: White surface, slight scaling.

Formula No. 9—Panel No. 18.

Zinc Oxide	73%	Chalking: None.
Silica	25%	Checking: Deep. Advanced tc peeling in places.
Calcium Carbonate	2%	General condition: Very poor.
	100%	Remarks: Film brittle and surface dark.

Formula No. 10—Panel No. 20.

Basic Carbonate — White Lead	44%	Chalking: Medium.
Zinc Oxide	46%	Checking: Slight lateral checking in places.
Calcium Carbonate	5%	General Condition: Good.
Asbestine	5%	Remarks: Surface very white.
	100%	

Formula No. 11—Panel No. 22.

Basic Carbonate — White Lead	50%	Chalking: Considerable.
Zinc Oxide	50%	Checking: Deep matt checking.
	100%	General Condition: Fair.
		Remarks: Considerable scaling. Formation of black coating shattered off.

Formula No. 12—Panel No. 24.

Basic Carbonate — White Lead	60%	Chalking: Medium.
Zinc Oxide	34%	Checking: Slight.
Inert Pigment	6%	General Condition: Fairly good.
	100%	Remarks: Surface white.

Formula No. 13—Panel No. 26.

Basic Sulphate—White Lead	60%	Chalking: Medium.
Zinc Oxide	27%	Checking: None.
Asbestine	10%	General Condition: Excellent.
Calcium Carbonate	3%	Remarks: Very white.
	100%	

Formula No. 14—Panel No. 28.

Basic Carbonate — White Lead	25%	Chalking: Considerable.
Basic Sulphate—White Lead	20%	Checking: Medium.
Zinc Oxide	25%	General Condition: Fair.
Calcium Sulphate	25%	Remarks: Panel fairly white.
Calcium Carbonate	5%	
	100%	

Formula No. 15—Panel No. 30.

Zinc Lead White	30%	Chalking: Slight.
Zinc Oxide	40%	Checking: Medium.
Basic Carbonate — White Lead	20%	General Condition: Good.
Calcium Carbonate	10%	Remarks: Surface quite dark.
	100%	

Formula No. 16—Panel No. 32.

Basic Carbonate — White Lead	33%	Chalking: Medium.
Zinc Oxide	33%	Checking: Very slight.
Barytes	34%	General Condition: Good.
	100%	Remarks: Quite white.

Formula No. 17—Panel No. 34.

Barytes	13%	Chalking: Considerable.
Blanc Fixe	4%	Checking: Slight. Along lateral lines.
Asbestine	3%	General Condition: Fair.
Zinc Oxide	40%	Remarks: Surface fairly white.
Basic Carbonate — White Lead	40%	
	100%	

Formula No. 18—Panel No. 36.

Basic Carbonate — White Lead (in oil)	75%	Chalking: Medium.
Zinc oxide (in oil)	25%	Checking: Slight, with some scaling.
	100%	General Condition: Good.
		Remarks: Surface has become quite dark.

Formula No. 19—Panel No. 38.

Basic Sulphate—White Lead (in oil)	75%	Chalking: Considerable.
Zinc Oxide (in oil)	25%	Checking: None.
	100%	General Condition: Excellent.
		Remarks: No black coating; surface very white; inertness of pigment or progressive chalking may have shed or prevented black coating.

Formula No. 20—Panel No. 40.

Basic Carbonate — White Lead 67.0%	Chalking: Medium.
Zinc Oxide 19.5%	Checking: Medium.
Asbestine 3.5%	General Condition: Good.
Calcium Carbonate 10.0%	
100.0%	

Formula No. 33—Panel No. 168.

Zinc Oxide 30%	Chalking: Heavy.
Special Silica 30%	Checking: None.
Basic Carbonate — White Lead 15%	General Condition: Fair.
Basic Sulphate—White Lead 25%	Remarks: White Surface.
100%	

Formula No. 34—Panel No. 172

Basic Carbonate—White Lead 38.95%	Chalking: Considerable.
Lead Sulphate 4.81%	Checking: Very slight.
Zinc Oxide 33.58%	General Condition: Good.
Calcium Carbonate 19.48%	Remarks: Surface is very white. Progressive chalking may have prevented any formation of black coating.
Barytes and Silica 3.18%	
100.00%	

Formula No. 35—Panel No. 173.

Basic Carbonate—White Lead 37.51%	Chalking: Bad.
Lead Sulphate 7.84%	Checking: None.
Zinc Oxide 25.87%	General Condition: Good.
Calcium Carbonate 20.36%	Remarks: Very white; no black coating evident.
Barytes and Silica 8.42%	
100.00%	

Formula No. 36—Panel No. 174.

Basic Carbonate — White Lead .... 100% Type B.	Chalking: Bad.
	Checking: Bad.
	General Condition: Fair.
	Remarks: Surface is dead black; shattered in places.

Formula No. 37—Panel No. 175.

Basic Carbonate — White Lead .... 100% Type C.	Chalking: Extremely bad. Checking: Medium. General Condition: Fair. Remarks: Very black surface and mottled in many places.

Formula No. 38—Panel No. 176.

Basic Carbonate — White Lead ....100% Type A.	Chalking: Very bad and quite dusty. Checking: Very bad, with scaling. General Condition: Poor. Remarks: Black surface is loose and shattered.

Formula No. 39—Panel No. 177.

Zinc Lead 100%	Chalking: Considerable. Checking: Slight. General Condition: Good. Remarks: Panel surface quite white.

Formula No. 40—Panel No. 178.

Sublimed White Lead 100%	Chalking: Very bad. Checking: Slight. General Condition: Good. Remarks: Surface very white, possibly due to progressive chalking or inertness of pigment.

Formula No. 45—Panel No. 169.

Zinc Oxide	90%	Chalking: Slight:
Calcium Carbonate	10%	Checking: Considerable.
	——	General Condition: Fair.
	100%	Remarks: White surface.

Formula No. 46—Panel No. 170.

Zinc Oxide 61%	Chalking: Slight.
Barytes 39%	Checking: Slight.
———	General Condition: Fair.
100%	Remarks: Considerable scaling present. Surface fairly white.

Formula No. 47—Panel No. 171.

Zinc Oxide 100%	Chalking:
Ground in special boiled oil.	Checking:
	General Condition:
	Remarks: Bad condition throughout.

Report on Special Tests Started in 1909 at Pittsburg and at Atlantic City

It will be remembered by those who read the First Annual Report on the Wearing of the Paints Applied to the Test Fences that all the lithophone formulas which were tested failed throughout; the panels on which these formulas were painted being removed from the fence and discarded from the test. It was suggested by certain members of the American Society for Testing Materials that new lithophone formulas be tested with different percentages of other pigments in combination, to replace the discarded tests. During the months of May and June, 1909 a series of new tests were therefore started, lithophone being mixed with various pigments in ascending proportions.

The use of zinc oxide and calcium carbonate in overcoming the darkening or fogging* of lithopone, preventing its excessive chalking, and increasing its durability, was suggested by several of the lithopone formulas applied in 1907. The results of this year's inspection of the new tests seem to show that a combination of the above-mentioned pigments, namely, lithopone, zinc oxide and whiting, in certain definite proportions, may give paints of some value for general exterior use. Excessive chalking is noted in some of these formulas, but promise of good results is indicated. Before venturing any more definite recommendation, however, it will be advisable to wait for the effect of another year's exposure.

*A brief study of the theory of solutions (See Cushman and Gardner on "Corrosion and Preservation of Iron and Steel"), involving the modes of ion formation, will be invaluable to the student who is inquiring into the cause of the peculiar fogging of lithopone, with the idea in view of correcting this evil by physical or chemical treatment. Inasmuch as our observations thus far have led us to believe that the fogging of lithopone takes place in the presence of moisture, with the contributory and necessary action of chemically active rays from the sun or other source, it is fair to assume that under these conditions the insoluble molecule of zinc sulphide and barium sulphate reverts by intricate molecular disturbance and ionization back to the soluble barium sulphate and zinc sulphide from which the lithopone is formed by metathesis. If this be true, then the acid nature of these soluble salts is no doubt combated and overcome at the moment of formation by the basic nature of zinc oxide and calcium carbonate, which tend to ionize to an alkaline reaction. The value of zinc oxide and calcium carbonate in lithopone paints, as detergents of blackness, has been demonstrated at both Atlantic City and Pittsburg." H. A. G.

Several grades of the pure white leads, and several high type composite paints were tested out at the same time with the lithopone panels, to act as criterions of the wearing value of the latter. The report of the committee on the condition of each, after one year's exposure follows, in table form. †

The most casual observation of those panels painted with lithopone combined with corroded white lead, shows that these two pigments are incompatible. It is apparent from a close inspection that the sulphide content of the lithopone has acted on the corroded white lead, with the production of lead sulphide which increases the darkness of the panel's surface.

The formulas which were not properly balanced and which had too high a percentage of lithopone presented a very rough, sandy surface, showing vehicle disintegration. They differed, however, from the surfaces of the corroded lead panels which were rough, in the form of checking, which was of a matted and veined appearance in the case of the lithopone panels

† The composition of the vehicle in all the new tests was standard, using pure linseed oil with a small percentage of turpentine drier. The tints used in each formula were secured at the time of application by the use of standard colors, lampblack and medium chrome yellow, using an approximate amount for each formula.

Analysis of Paint Pigments Applied to the Pittsburg and Atlantic City Test Fences, June, 1909

Pittsburg, Pa., April 11, 1910.

MR. HENRY A. GARDNER, Director.

Scientific Section, Paint Manufacturers' Association of the U. S.,

3500 Gray's Ferry Road, Philadelphia, Pa.

Dear Sir—

I herewith submit the analyses made by Dr. Stevens and myself of the paints placed on the Pittsburg and Atlantic City Test Fences during June, 1909.

The oil was extracted from the paints by repeated centrifuging with benzine. The small amount of oil which remained, and the soap which had formed on standing were deducted from the pigments, which were then calculated to 100%. This unextracted matter ran approximately 2% in each case.

Repeated analyses were made in each case, so as to get absolute confirmation of results.

Very truly yours,

DR. JOHN A. SCHAEFFER,

Carnegie Technical Schools, Pittsburg, Pa.

Formula No.	Supposed Composition		Found on Analysis
1—	Lithopone	40%	41.67%
	Basic Sulphate—White Lead	45%	43.86%
	Calcium Carbonate	15%	14.47%
		100%	100.00%
2—	Lithopone	40%	41.31%
	Basic Sulphate—White Lead	45%	43.45%
	Silica	15%	15.24%
		100%	100.00%

Formula No.	Supposed Composition		Found on Analysis
3—	Lithopone	45%	43.39%
	Zinc oxide	45%	45.32%
	Calcium Carbonate	10%	11.29%
		100%	100.00%
4—	Lithopone	45%	48.10%
	Basic Sulphate—White Lead	45%	42.83%
	Calcium Carbonate	10%	9.07%
		100%	100.00%
*5—	Lithopone	40%	46.44%
	Zinc Oxide	40%	27.36%
	Calcium Carbonate	20%	26.20%
		100%	100.00%
6—	Lithopone	35%	35.47%
	Basic Sulphate—White Lead	45%	44.43%
	Asbestine	20%	20.10%
		100%	100.00%
7—	Basic Carbonate—White Lead	50%	53.22%
	Zinc Lead	36%	36.00%
	China Clay	8%	7.74%
	Barytes	4%	2.00%
	Asbestine	2%	1 04%
		100%	100.00%
8—	Basic Sulphate—White Lead	50%	50.26%
	Lithopone	36%	35.34%
	Clay	8%	8.36%
	Barytes	4%	3.64%
	Asbestine	2%	2.40%
		100%	100.00%

*On account of the formation of zinc compounds with the vehicle and subsequent oxidation, it was impossible to make a satisfactory extraction of No. 5, as part of the vehicle was solid at ordinary temperatures and liquid at 100 degrees. After repeated attempts the above analysis is submitted as the best obtainable.

Formula No.	Supposed Composition		Found on Analysis
9—	Basic Sulphate—White Lead	50%	47.35%
	Lithopone	36%	38.09%
	Barytes	12%	12.00%
	Asbestine	2%	2.56%
		100%	100.00%
10—	Basic Sulphate—White Lead	50%	48.30%
	Zinc Oxide	36%	37.39%
	China Clay	8%	7.96%
	Barytes	4%	4.26%
	Asbestine	2%	2.09%
		100%	100.00%
11—	Basic Carbonate—White Lead	28%	30.45%
	Zinc Oxide	55%	54.77%
	Blanc Fixe	7%	12.08%
	Barytes	7%	
	Asbestine	3%	2.70%
		100%	100.00%
12—	Basic Sulphate—White Lead	28%	27.57%
	Zinc Oxide	55%	57.99%
	Blanc Fixe	7%	12.35%
	Barytes	7%	
	Asbestine	3%	2.09%
		100%	100.00%
13—	Lithopone	30%	33.20%
	Zinc Oxide	60%	57.90%
	Calcium Carbonate	10%	8.90%
		100%	100.00%
14—	Lithopone	30%	30.73%
	Zinc Oxide	30%	31.55%
	Basic Sulphate—White Lead	30%	27.68%
	Calcium Carbonate	10%	10.04%
		100%	100.00%

Formula No.	Supposed Composition		Found on Analysis
15	Lithopone	30%	36.40%
	Basic Sulphate—White Lead	60%	54.39%
	Calcium Carbonate	10%	9.21%
		100%	100.00%
16	Lithopone	100%	Lithopone 100.00%
			Barium Sulphate 71.95%
			Zinc Sulphide 25.52%
			Zinc Oxide 2.53%
17	Lithopone	100%	Lithopone 100.00%
			Barium Sulphate 71.85%
			Zinc Sulphide 24.90%
			Zinc Oxide 3.25%
18	Basic Carbonate—White Lead	33%	33.90%
	Zinc Oxide	33%	33.70%
	Silica	17%	32.40%
	China Clay	17%	
		100%	100 00%
19	Basic Carbonate—White Lead	34%	35.49%
	Zinc Oxide	33%	29.60%
	Silica	33%	34.91%
		100%	100.00%
20	Basic Carbonate—White Lead	34%	33.34%
	Zinc Oxide	33%	33.24%
	Clay	33%	33.42%
		100%	100.00%
21	Basic Carbonate—White Lead. Type S.	100%	Basic Carbonate—White Lead 100.00%
22	Basic Carbonate—White Lead.	100%	Zinc Lead 100.00%
			Zinc Oxide 47.30%
			Lead Sulphate 52.70%
			100.00%
23	Basic Carbonate—White Lead. Type C.	100%	Basic Carbonate—White Lead 100.00%

Formula No.	Supposed Composition		Found on Analysis
24	Basic Sulphate—White Lead..100%		Basic Sulphate—White Lead ...100.00%
	Basic Sulphate—White Lead	89.36%	
	Zinc Oxide	10.64%	
		100.00%	
25	Zinc Lead 100%		Zinc Lead 100%
	Zinc Oxide	50.14%	
	Lead Sulphate ...	49.86%	
		100.00%	
26	Basic Carbonate—White Lead.100% Type M.		Basic Carbonate—White Lead 100.00%
27	Basic Carbonate—White Lead.100% Mild Process.		Basic Carbonate—White Lead 100.00%
28	Basic Carbonate—White Lead.100% B. B.		Basic Carbonate—White Lead 100.00%
29	Basic Carbonate—White Lead	24%	25.52%
	Basic Sulphate—White Lead..	13%	14.77%
	Zinc Oxide	45%	44.66%
	Asbestine	18%	15 05%
		100%	100.00%
30	Lithopone	40%	39.59%
	Basic Carbonate—White Lead	45%	48.43%
	Calcium Carbonate	15%	12.08%
		100%	100.00%
31	Lithopone	40%	39.81%
	Basic Carbonate—White Lead	45%	44.92%
	Silex	15%	15.27%
		100%	100.00%
32	Lithopone	35%	36.78%
	Basic Carbonate—White Lead	45%	44.99%
	Asbestine	20%	18.23%
		100%	100.00%

Formula No.	Supposed Composition			Found on Analysis
33—	Lithopone	36%		36.00%
	Basic Carbonate—White Lead	50%		51.26%
	Barytes	12%		10.80%
	Asbestine	2%		1.94%
		100%		100.00%
34—	Basic Carbonate—White Lead	75%		83.00%
	Basic Sulphate—White Lead..	25%		17.00%
		100%		100.00%
35—	Basic Sulphate—White Lead..	50%		34.09%
	Basic Carbonate—White Lead	50%		65.91%
		100%		100.00%
36—	Silica	100%		
	Silica		95.00%	
	Barytes		3.78%	
	Alumnia		1.22%	
			100.00%	

Inspection of 1909 Test, Pittsburg

Formula No. 1—Panel No. 1.

Lithopone	40%	Chalking: Considerable.
Basic Sulphate—White Lead	45%	Checking: Slight.
Calcium Carbonate	15%	General Condition: Fair.
	100%	Remarks: Dark in places. Diffused.

Formula No. 2—Panel No. 2.

Lithopone	40%	Chalking: Slight.
Basic Sulphate—White Lead	45%	Checking: Bad.
Silica	15%	General Condition: Fair.
	100%	Remarks: Dark in places.

Formula No. 3—Panel No. 3.

Lithopone	45%	Chalking: Medium.
Zinc Oxide	45%	Checking: None.
Calcium Carbonate	10%	General Condition: Good.
	100%	Remarks: Darkening shown in places.

Formula No. 4—Panel No. 4.

Lithopone	45%	Chalking: Considerable.
Basic Sulphate—White Lead	45%	Checking: None
Calcium Carbonate	10%	General Condition: Good.
	100%	Remarks: Medium dark.

Formula No. 5—Panel No. 5.

Lithopone	40%	Chalking: Slight.
Zinc Oxide	40%	Checking: None.
Calcium Carbonate	20%	General Condition: Good.
	100%	Remarks: No excessive darkness.

TESTS INAUGURA D IN 1909
RESULTS OF INSPECTION OF PITTS URG TEST FENCE, MAY, 1910

Formula Number	FORMULAS: Basic Carbonate White Lead	Zinc Oxide	Basic Sulphate White Lead	Precipitated White Lead	Zinc Lead	Lithopone	INERT PIGMENTS: Calcium Carbonate	Silica	Asbestine	China Clay	Barytes	Blanc Fixe	REPORT OF INSPECTION: Chalking	Checking	General Condition	Remarks	Panel Number
		%			%	%	%	%	%	%	%	%					
1			45			40	15						Considerable	Slight	Fair	Dark in places. Diffused	1
2			45			40		15					Slight	Bad	Fair	Dark in places	2
3		45				45	10						Medium	None	Good	Darkening shown in places	3
4			45			45	10						Considerable	None	Good	Medium dark	4
5		40				40	20						Slight	None	Good	No excessive darkness	5
6			45			35			20				Medium	Slight	Good	Surface fairly white	6
7	50				36				2	8	4		Medium	None	Excellent	Whitest surface of new tests	7
8			50			36			2	8	4		Extremely bad	Slight	Fair	Surface darkening	8
9			50			36			2		12		Extremely bad	Slight	Fair	Not as bad as No. 8	9
10		36	50						2	8	4		Slight	None	Good	Excellent surface; very white.	10
11	28	55							3		7	7	Slight	None	Excellent.	Surface fairly white; thin soot	11
12		55	28						3		7	7	Medium	None	Good	Surface white.	12
13		60				30	10						Medium	Very bad in spots	Fair	Slight darkening	13
14		30	30			30	10						Heavy	Considerable	Fair	Slight darkening	14
15			60			30			10				Extremely bad	Slight	Fair	Fairly white	15
16						100							Extremely bad	Advanced and deep	Bad.	Surface rough with considerable disintegration and much darkness	16
17						100							Not as bad as #1	Less advanced than No. 16	Fair	Not as dark as No. 16; slightly mottled in places; buff color	17
18	33	33						17		17			Very slight	Practically none	Fair	Surface white	18
19	34	33						33					Very slight	None	Good	Surface fairly white	19
20	34	33								33			None	None	Good	Surface fairly white	20
21	100												Slight.	Slight	Fair	Surface very rough and dark	21
22	100*												Medium	Slight	Fair	Surface fairly white	22
23	100												Slight	Bad	Fair	Surface rough and darkest on fence	23
24			100										Bad.	None.	Good	Surface white	24
25					100								Slight	None.	Good	Fairly white surface	25
26				100									Medium	Slight.	Fair	Rough and very dark; chalking is disrupting black coating	26
27	100												Medium.	Slight.	Good	Surface fairly white	27
28	100												Medium.	Deep; evident without glass	Poor	Surface rough and very dark	28
29	24	45	13						18				Slight.	Slight.	Good	Very white surface	29
30	45					40	15						None	Slight.	Fair	Color dark	30
31	45					40		15					Very slight	Advanced	Fair	Color very dark	31
32	45					35			20				Extremely sligh	Considerable.	Fair	Color very dark; rough surface	32
33	50					36			2		12		Extremely sligh	Slight.	Fair	Surface dark and rough	33
34	75		25										Slight	Deep.	Fair	Surface medium dark	34
35	50		50										Considerable	Slight.	Fair	Surface medium dark	35
36								100					Extremely bad	None.	Fair	Vehicle disintegrated, leaving very white, chalked surface of pigment	36

* This pigment on analysis proved to be zinc lead. See Report on Analysis.

Formula No. 6—Panel No. 6.

Lithopone	35%
Basic Sulphate—White Lead	45%
Asbestine	20%
	100%

Chalking: Medium.
Checking: Slight.
General Condition: Good.
Remarks: Surface fairly white.

Formula No. 7—Panel No. 7.

Basic Carbonate — White Lead	50%
Zinc Lead	36%
China Clay	8%
Barytes	4%
Asbestine	2%
	100%

Chalking: Medium.
Checking: None.
General Condition: Excellent.
Remarks: Very white surface. Appears to be the whitest surface of any in the new tests.

Formula No. 8—Panel No. 8.

Basic Sulphate—White Lead	50%
Lithopone	36%
China Clay	8%
Barytes	4%
Asbestine	2%
	100%

Chalking: Extremely bad.
Checking: Slight.
General Condition: Fair.
Remarks: Surface darkening.

Formula No. 9—Panel No. 9.

Basic Sulphate—White Lead	50%
Lithopone	36%
Barytes	12%
Asbestine	2%
	100%

Chalking: Extremely Bad.
Checking: Slight.
General Condition: Fair.
Remarks: Not as bad as No. 8.

Formula No. 10—Panel No. 10.

Basic Sulphate—White Lead	50%
Zinc Oxide	36%
China Clay	8%
Barium Sulphate	4%
Asbestine	2%
	100%

Chalking: Slight.
Checking: None.
General Condition: Good.
Remarks: Excellent surface shown. Very white.

Formula No. 11—Panel No. 11.

Basic Carbonate — White Lead	28%	Chalking: Slight.
Zinc Oxide	55%	Checking: None.
Blanc Fixe	7%	General Condition: Excellent.
Barytes	7%	Remarks: Surface fairly white. Thin soot.
Asbestine	3%	
	100%	

Formula No. 12—Panel No. 12.

Basic Sulphate—White Lead	28%	Chalking: Medium.
Zinc Oxide	55%	Checking: None.
Blanc Fixe	7%	General Condition: Good.
Barytes	7%	Remarks: Surface white.
Asbestine	3%	
	100%	

Formula No. 13—Panel No. 13.

Lithopone	30%	Chalking: Medium.
Zinc Oxide	60%	Checking: Very bad in spots.
Calcium Carbonate	10%	General Condition: Fair.
		Remarks: Slight darkening.
	100%	

Formula No. 14—Panel No. 14.

Lithopone	30%	Chalking: Heavy.
Zinc Oxide	30%	Checking: Considerable.
Basic Sulphate—White Lead	30%	General Condition: Fair.
Calcium Carbonate	10%	Remarks: Slight darkening.
	100%	

Formula No. 15—Panel No. 15.

Lithopone	30%	Chalking: Extremely bad.
Basic Sulphate—White Lead	60%	Checking: Slight.
Asbestine	10%	
		General Condition: Fair.
	100%	Remarks: Fairly white.

Formula No. 16—Panel No. 16.

Lithopone ....100% Ground in linseed oil with 5% chrome resinate.	Chalking: Extremely bad. Checking: Advanced and deep. General Condition: Bad. Remarks: Surface rough with considerable disintegration and panel very dark. Early failure predicted.

Formula No. 17—Panel No. 17.

Lithopone ....100% Ground in linseed oil with 2% zinc resinate to be thinned for spreading with turpentine and spar varnish for high gloss.	Chalking: Not as bad as No. 16. Checking: Less advanced than No. 16. General Condition: Fair. Remarks: Surface not as dark as No. 16. Slightly mottled in places. Buff color.

Formula No. 18—Panel No. 18.

Basic Carbonate — White Lead .... 33% Zinc Oxide .... 33% Silica .... 17% Kaolin 17% 100%	Chalking: Very slight. Checking: Practically none. General Condition: Fair. Remarks: Surface white.

Formula No. 19—Panel No. 19.

Basic Carbonate — White Lead .... 34% Zinc Oxide .... 33% Silica 33% 100%	Chalking: Very slight. Checking: None. General Condition: Good. Remarks: Surface fairly white.

Formula No. 20—Panel No. 20.

Basic Carbonate — White Lead .... 34% Zinc Oxide .... 33% Kaolin 33% 100%	Chalking: None. Checking: None. General Condition: Good. Remarks: Surface fairly white.

Formula No. 21—Panel No. 21.

Basic Carbonate — White Lead ....100% S.	Chalking: Slight. Checking: Slight. General Condition: Fair. Remarks: Surface very rough and very dark.

Formula No. 22*—Panel No. 22.

Basic Carbonate — White Lead ....100% E.	Chalking: Medium. Checking: Slight. General Condition: Fair. Remarks: Surface fairly white.

Formula No. 23—Panel No. 23.

Basic Carbonate — White Lead ....100% C.	Chalking: Slight. Checking: Bad. General Condition: Fair. Remarks: Surface rough and darkest on fence.

Formula No. 24—Panel No. 24.

Basic Sulphate — White Lead 100%	Chalking: Bad. Checking: None: General Condition: Good. Remarks: Surface white.

Formula No. 25—Panel No. 25.

Zinc Lead 100%	Chalking: Slight. Checking: None. General Condition: Good. Remarks: Fairly white surface.

Formula No. 26—Panel No. 26.

Basic Carbonate — White Lead ....100% M.	Chalking: Medium. Checking: Slight. General Condition: Fair. Remarks: Surface rough and very dark. Chalking is disrupting black coating.

*This pigment on analysis proved to be zinc lead white. See Report on Analysis.

Formula No. 27—Panel No. 27.

Basic Carbonate — White Lead ....100% Mild process.	Chalking: Medium. Checking: Slight. General Condition: Good. Remarks: Surface fairly white.

Formula No. 28—Panel No. 28.

Basic Carbonate — White Lead ....100% B.-B.	Chalking: Medium. Checking: Deep; evident without use of glass. General Condition: Poor. Remarks: Surface Rough and very dark.

Formula No. 29—Panel No. 29.

Basic Carbonate — White Lead .... 24% Basic Sulphate—White Lead 13% Zinc Oxide .... 45% Asbestine 18% 100%	Chalking: Slight. Checking: Slight. General Condition: Good. Remarks: Very white surface.

Formula No. 30—Panel No. 30.

Lithopone .... 40% Basic Carbonate — White Lead .... 45% Calcium Carbonate 15% 100%	Chalking: None. Checking: Slight. General Condition: Fair. Remarks: Color dark.

Formula No. 31—Panel No. 31.

Lithopone .... 40% Basic Carbonate — White Lead .... 45% Silica 15% 100%	Chalking: Very slight. Checking: Advanced. General Condition: Fair. Remarks: Color very dark.

Formula No. 32—Panel No. 32.

Lithopone 35%	Chalking: Extremely slight.
Basic Carbonate — White Lead 45%	Checking: Considerable.
Asbestine 20%	General Condition: Fair.
100%	Remarks: Color very dark and rough.

Formula No. 33—Panel No. 33.

Lithopone 36%	Chalking: Extremely slight.
Basic Carbonate — White Lead 50%	Checking: Slight.
Barytes 12%	General Condition: Fair.
Asbestine 2%	Remarks: Surface dark and rough
100%	

Formula No. 34—Panel No. 34.

Basic Carbonate — White Lead 75%	Chalking: Slight.
Basic Sulphate—White Lead 25%	Checking: Deep.
100%	General Condition: Fair.
	Remarks: Surface medium dark.

Formula No. 35—Panel No. 35.

Basic Sulphate—White Lead 50%	Chalking: Considerable.
Basic Carbonate — White Lead 50%	Checking: Slight.
100%	General Condition: Fair.
	Remarks: Surface medium dark.

Formula No. 36—Panel No. 36.

Silica 100%	Chalking: Extremely bad.
	Checking: None.
	General Condition: Fair.
	Remarks: Vehicle disintegrated, leaving very white, chalked surface of pigment.

Repainting Tests in 1910 at Pittsburg

Repainting tests were made during May, 1910, on the first set of tests, painted originally in 1907. The work was in charge of Mr. Alfred C. Rapp, the master painter representing the Pittsburg Master Painters' Association, who has had charge of the painting of all the tests placed on the Pittsburg Test Fence. Dr. Schaeffer, representing the Carnegie Technical Schools Test Fence Committee, was constantly in attendance during the application of the paints in the new test, supervising the reductions and keeping the records.

Previous to repainting the panels, the small sections which had been used in the laboratory for microscopic work were returned to their respective positions. Each panel was lightly sandpapered and brushed free from adhering dirt, soot or scale. Two coats of white paint were applied on each white pine panel; the yellow and gray tints of paint, and the other grades of wood being omitted from the test. The paints were furnished in sealed packages, properly numbered and tabulated, being part of the original supply and of the same composition as used in the first test during 1907. The usual methods of carrying on field tests were observed in the repainting tests, care being taken to clean the brushes before applying the different formulas and to record all the conditions. An inspection of these repainted surfaces will be made next year.

CATALOGUE

Library of the Scientific Section

Analytical Chemistry—Volumes 1 and 2 —*Treadwell-Hall*
A History of Decorative Art —*W. Norman Brown*
An Outline of the Theory of Solution and Its Results —*J. L. R. Morgan*
A Treatise on Color Manufacture —*Zerr & Rubencamp*
Bulletins of the Census Bureau.
Cements, Limes and Plasters —*Edwin C. Eckel*
Chemistry and Technology of Mixed Paints —*M. Toch*
Chemistry of Paint and Paint Vehicles —*C. H. Hall*
Chemistry of Paints and Painting —*A. H. Church*
Chemical Technology and Analysis of Oils, Fats and Waxes, Vols. 1 and 2 —*J. Lewkowitsch*
Chemiker-Kalendar—1908.
Clays, Their Occurrence, Properties and Uses —*Heinrich Ries*
Corrosion and Preservation of Iron and Steel —*A. S. Cushman and H. A. Gardner*
Determinative Mineralogy and Blowpipe Analysis —*Brush-Penfield*
Dictionary of Chemicals and Raw Products —*G. H. Hurst*
Used in the Manufacture of Paints, Colors, Varnishes and Allied Preparations
Drying Oils, Boiled Oil and Solid and Liquid Driers —*L. E. Andes*
A Practical Work for Manufacturers of Paints, Oils, Varnishes, etc.
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Handbook on Petroleum —*Thomson Redwood*
A Treatise on the Industrial Use of its Products.
House Decorating and Painting —*W. Norman Brown*
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Containing Directions for the Manufacture of All Artificial Artists' and Painters' Colors, Enamel Colors, Soot and Metallic Pigments

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Notes on Lead Ores —*Jos. Fairie*

Their Distribution and Properties

Notes on the Structure of Paint Films —*L. S. Hughes*

Oil Analysis —*Augustus H. Gill*

Oil Chemists' Handbook —*E. Hopkins*

Oil Colors and Printers' Inks —*L. E. Andes*

A Practical Handbook Treating of Linseed Oil, Boiled Oil, Paints, Artists' Colors, Lamp Black, and Printers' Inks

One Thousand More Paint Questions Answered.

Outlines of Inorganic Chemistry —*Gooch & Walker*

Outlines of Qualitative Chemical Analysis —*Gooch & Browning*

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A Practical Book for Practical Men

Principles of Mining —*Herbert C. Hoover*

Principles of Reinforced Concrete Construction —*Turneaure & Maurer*

Proceedings of the American Society for Testing Materials—11th Annual Meeting.

Quantitative Chemical Analysis by Electrolysis —*Classen-Boltwood*

Report of Tariff Committee, Paint Manufacturers' Association of the United States, 1909.

Rustless Coatings, Corrosion and Electrolysis of Iron and Steel —*M. P. Wood*

Simple Methods for Testing Painters' Materials —*A. C. Wright*

A Handbook on Paints, Colors and Varnishes

Spectrum Analysis —*Laudauer-Tingle*

Students' Handbook of Paints, Colors, Oils and Varnishes—*John Furnell*

Table of Minerals —*Samuel Lewis Penfield*

Including the Uses of Minerals and Statistics of the Domestic Production

Techno-Chemical Analysis —*Lunge-Cohn*
Technology of Paint and Varnish —*A. H. Sabin*
Testing and Valuation of Raw Materials Used in Paint and Color Manufacture —*M. W. Jones*
Tests and Reagents, Chemical and Microscopical —*A. L. Cohn*
Text-book of Chemical Arithmetic —*H. L. Wells*
The Chemistry of Photography —*Raphael Meldola*
The Chemistry of Pigments —*Parry & Coste*
The Colorist —*J. A. H. Hatt*
The Corrosion of Iron and Steel —*Alfred Sang*
The Electric Furnace —*Alfred Stansfield*
The Lead and Zinc Pigments —*C. D. Holley*
The Manufacture of Lake Pigments from Artificial Colors —*F. H. Jennison*
The Manufacture of Varnishes and Kindred Industries—2 Vols. —*Livache and McIntosh*
The Microscope —*S. H. Gage*
The Theory and Practice of Enamelling on Iron and Steel —*Grünwald-Hodgson*
The Volatile Oils —*Gildmeister and Hoffman*
Transactions of the American Electrochemical Society, 1909.

Pamphlets

- Corrosion of Fence Wire —*A. S. Cushman*
- The Analysis of Turpentine by Fractional Distillation with Steam —*Wm. C. Geer*
- The Corrosion of Iron —*A. S. Cushman*
- Some Technical Methods of Testing Miscellaneous Supplies —*P. H. Walker*

Periodicals:

- Chemical Abstracts
- Drugs, Oils and Paints
- Journal of Industrial and Engineering Chemistry
- Journal of the American Chemical Society
- Journal of the Society of Chemical Industry
- Metallurgical and Chemical Engineering
- Oil, Paint and Drug Reporter
- The American Paint and Oil Dealer
- The Canadian Painter and Decorator
- The Decorator
- The Master Painters' Journal
- The Painters' Magazine

Publications of the Scientific Section

EDUCATIONAL BUREAU

PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

Bulletin
Number

Preliminary Booklet—Addresses on Paint, Delivered Before the Michigan Chapter, American Institute of Architects, 1907. (*Out of print.*)

1—Tables of White Pigments and Vehicle—Standard Nomenclature.

2—Standard Can Sizes Recommended to Paint Manufacturers.

3—First Report on the Test Fences Erected by the Scientific Section. (*Out of print.*)

4—Methods for the Analysis of the Vehicle Constituents of Paint. (*Out of print.*)

5—Tests Upon the Corrosion of Iron to be Conducted by the Scientific Section. (*Out of print.*)

6—First Annual Report of the Scientific Section.

7—Preliminary Report on Steel Test Fences.

8—Report of Committee "E" on Preservative Coatings for Iron and Steel. (*Out of print.*)

9—Recent Technical Developments in Paint Manufacture.

10—Protective Coatings for Conservation of Structural Material.

11—The Corrosion of Iron and Steel. *By Alfred Sang.* (*Out of print.*)

12—The Function of Oxygen in the Corrosion of Metals. *By William H. Walker.*

Bulletin
Number

13—Protective Coatings for Steel and Iron. *By Robert S. Perry.* (*Out of print.*)

14—Coatings for the Conservation of Structural Material. (*Out of print.*)

15—Protective Coatings for Structural Material. *By R. S. Perry.*

16—First Annual Report on Wearing of Paints Applied to Atlantic City Test Fence.

17—First Annual Report on Wearing of Paints Applied to Pittsburg Test Fence.

18—First Annual Report on Atlantic City Steel Test Fence.

19—Laboratory Study of Panels on Atlantic City and Pittsburg Test Fences. (*Out of print.*)

20—Concrete Coatings. *By H. A. Gardner.*

21—A Brief Talk on Paints. *By Henry A. Gardner.* (*Out of print.*)

22—Annual Report for 1909.

Preliminary Bulletin—Second Edition—Physical Characteristics of a Paint Coating. *By R. S. Perry.*

23--The Theory of Driers, Etc.

24—Some Iron Oxides and Their Values.

25—Report on Examination of North Dakota Test Fences.

Special Bulletin—Scientifically Prepared Paints and Laws Governing Their Manufacture. *By Henry A. Gardner.*

An Exhibition of Certain Analogies Governing the Manufacture of Concrete and of Paint. *By R. S. Perry.*

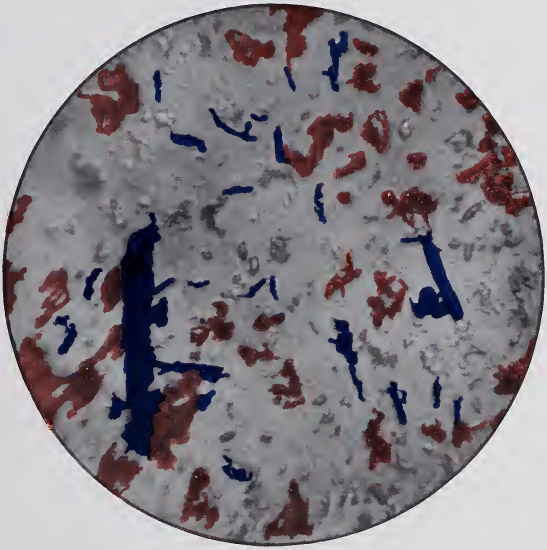
26—Second Annual Report on Wearing of Paints Applied to Atlantic City Test Fence.

27—Second Annual Report on Atlantic City Steel Test Fence

28—Second Annual Report on Wearing of Paints Applied to Pittsburg Test Fence.

Bulletin No. 29

THE PROPERTIES AND STRUCTURE OF CERTAIN PAINT PIGMENTS



Photomicrograph of Mixed Paint, Showing the White Lead Particles in Red, the Zinc Oxide in Black, and the Asbestine in Blue

SCIENTIFIC SECTION—EDUCATIONAL BUREAU

HENRY A. GARDNER, Director

PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

Philadelphia, Pa.

The Properties and Structure of Certain Paint Pigments

BY

HENRY A. GARDNER

Director Scientific Section, Educational Bureau

Paint Manufacturers' Association of the U. S.

AND

JOHN A. SCHAEFFER

Instructor in Chemical Practice, Carnegie Technical Schools

Pittsburg, Pa.

SCIENTIFIC SECTION—EDUCATIONAL BUREAU

HENRY A. GARDNER, Director

PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

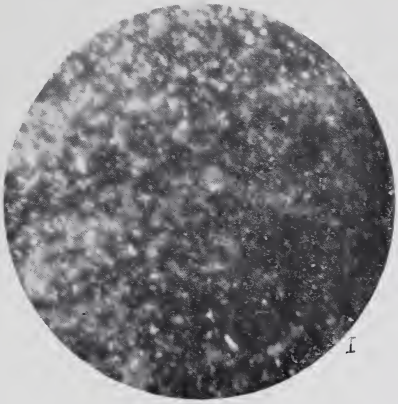
Philadelphia, Pa.

PREFACE

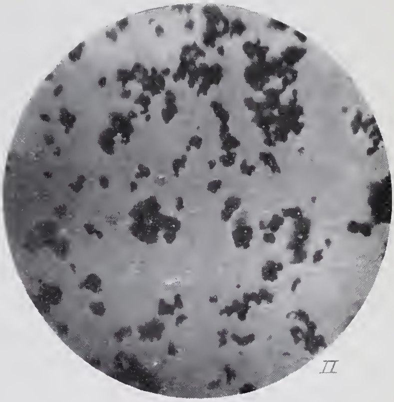
IT IS the belief of the authors that the microscopic study of pigments is of great importance to the paint manufacturer. A careful microscopic research not only divulges the physical peculiarities and characteristics of each pigment, but offers an explanation of certain phenomena attending their use.

The micro-analysis of paint has not been developed thus far, beyond the qualitative stage, but there is every hope that future studies may bring into practice the quantitative micro-analysis of the various constituents of a paint.

The photomicrographs shown in this book are all enlarged 422 diameters.



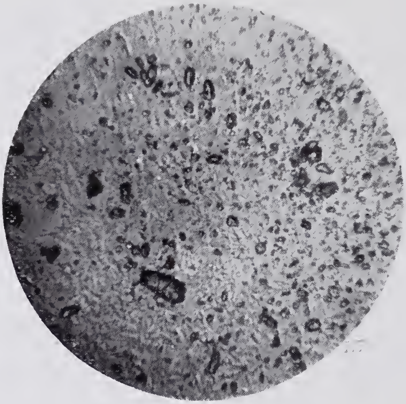
BY POLARIZED LIGHT



BY TRANSMITTED LIGHT

BASIC CARBONATE-WHITE LEAD.

This pigment is made by stacking clay pots which contain dilute acetic acid and lead buckles, in tiers, and covering them with tan bark. Fermentation of the tan bark, with subsequent formation of carbon dioxide acting on the acetate of lead formed within the pots, produces basic carbonate of lead. After complete corrosion, the white lead is ground, floated and dried. Basic carbonate of lead has a specific gravity of 6.8 and contains about 85 per cent. lead oxide and 15 per cent. of carbon dioxide and water. Its opaque nature and excellent body renders it extremely valuable as a pigment, and its life and wearing properties are increased when mixed with zinc oxide and many other pigments. Checking and chalking progress rapidly when the pigment is used alone. The various sized particles, both large and small, resulting from a corrosion process, may be readily noted from the photomicrograph of the pigment.



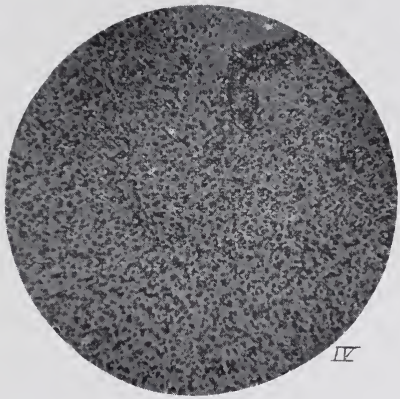
WHITE LEAD (QUICK PROCESS).

By acting on atomized metallic lead, contained within large revolving wooden cylinders, with dilute acetic acid, and carbon dioxide, the quick process white lead is produced. Its value is equal to the Dutch process white lead and is considered by some as possessing greater spreading value.

WHITE LEAD (MILD PROCESS).

Briefly, the Mild Process of manufacturing white lead consists of first melting the pig lead and converting it into the finest kind of lead powder, then mixing thoroughly with air and water. The lead takes up water and oxygen from the air, thus forming a basic hydroxide of lead. Carbon dioxide gas is next pumped slowly through the cylinders which contain the basic hydroxide of lead. The result is basic carbonate of lead—the dry white lead of commerce.

The process is called "Mild" because it is the mildest process possible for the manufacture of white lead. It is the only method in practical operation which does not require the use of acids, alkalis or other chemicals, every trace of which should be removed from the finished product by expensive purifying processes. The failure of such washing and purifying means a product of inferior quality which necessarily reduces the durability of any paint in which it is used.

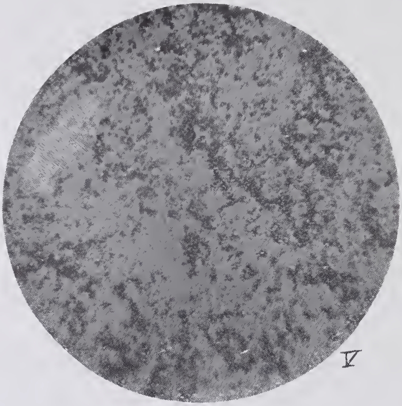


BASIC SULPHATE-WHITE LEAD.

(Sublimed White Lead.)

By the action of the oxygen of the air on the fume produced by the roasting and subsequent volatilization of galena, this fine, white, amorphous pigment is made. On analysis, its composition shows approximately 70 per cent. of lead sulphate, 20 per cent. of lead oxide and 5 per cent. of zinc oxide. It has a specific gravity of 6.2. Possessed of extreme stability, it finds wide use as a constituent of paints and as a base for tinting colors. It is readily soluble in ammonium acetate.

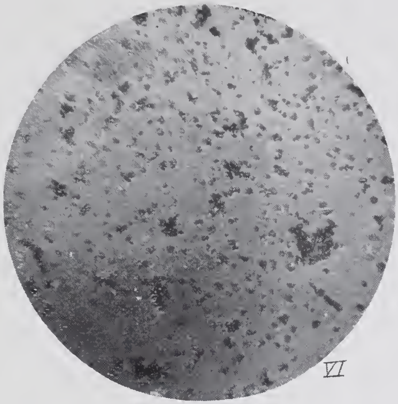
The photomicrograph of this pigment shows its extremely fine, amorphous nature, with complete absence of crystals. In fineness it is almost identical with zinc oxide.



ZINC OXIDE.

This extremely white and fine pigment is prepared either by the roasting and sublimation of zincite and franklinite, or the sublimation and oxidation of spelter. Its purity approaches in most instances 99.5 or more. It has a specific gravity of 5.2. On account of its stability, whiteness, opaque nature and slight tendency to chalk, it is invaluable as a pigment when a constituent in a combination formula. Its extreme hardness renders it less resistant to temperature changes, when used alone. Zinc oxide dissolves to a clear solution in all mineral acids.

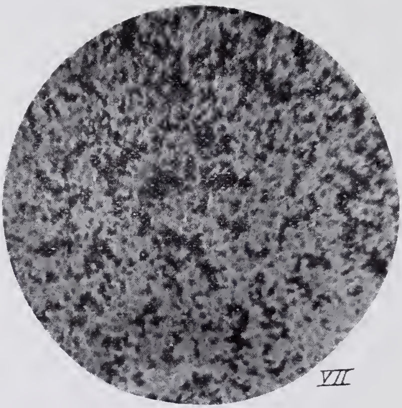
Under the microscope the fineness and structure of the particles are clearly evident.



VI

ZINC LEAD WHITE.

This extremely fine pigment, consisting of about equal parts of zinc oxide and lead sulphate, results from the reduction, volatization and subsequent oxidation of sulphur-bearing lead and zinc ores. It has a specific gravity of 4.4. Its slightly yellowish tint bars it from being used alone very extensively, but when mixed with white lead, zinc oxide and inert pigments, or used as a base for colored paints, it is of considerable value. Being somewhat inhibitive in nature, it is of use as a protective coating for iron and steel. The magnification of the particles shows the peculiar way in which the pigment agglomerates and the peculiar characteristics of a fine, uniform pigment.

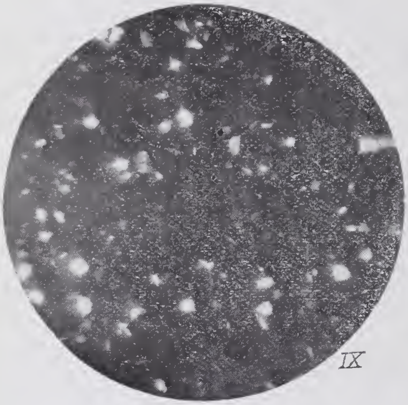


LITHOPONE.

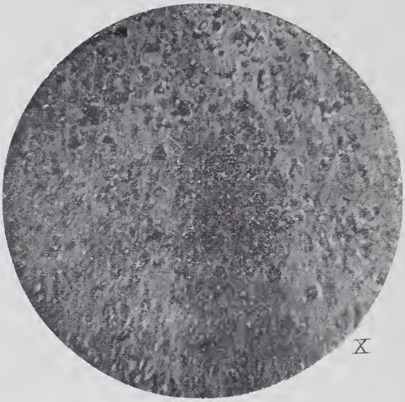
Lithopone, probably the whitest of pigments, results from the double decomposition of zinc sulphate and barium sulphide, thereby forming a molecular combination of zinc sulphide and barium sulphate. The peculiar property which it possesses, of darkening under the actinic rays of the sun, makes it essential that it be combined with other, more stable pigments to prolong its life when exposed to weather. Lithopone contains approximately 70 per cent. barium sulphate, 25 to 28 per cent. zinc sulphide, and as high as 5 per cent. of zinc oxide. Its specific gravity is about 4.25. It is excellently suited for interior use in the manufacture of enamels and wall finishes. When properly mixed with other pigments, such as zinc oxide and calcium carbonate, fair results are obtained as a pigment for outside work. Lead pigments are never used with lithopone, as lead sulphide results, giving a black appearance. The characteristic flocculent, non-crystalline appearance is plainly evident when examined under the microscope.

MAGNESIUM SILICATE (ASBESTINE).

The very characteristic fibrous structure of this pigment shows clearly under the microscope. Its extremely stable nature renders it of great value as a reinforcing pigment for outside paints. Its gravity, 2.7, is comparatively low, and when this pigment is used in ready-mixed paints, it tends to prevent any heavy pigments from settling. It serves to greatly strengthen the paint coating.



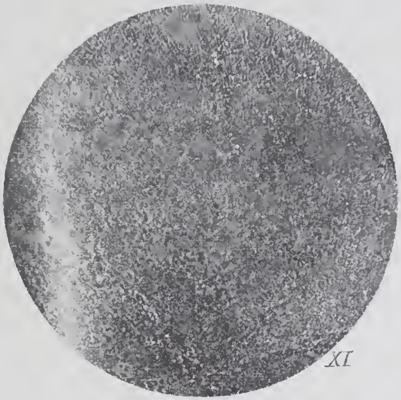
BY POLARIZED LIGHT



BY TRANSMITTED LIGHT

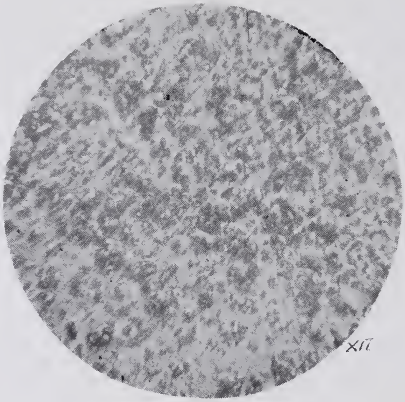
BARIUM SULPHATE (BARYTES).

By grinding the crude ore, treating with acid to remove the iron, and finally washing, floating and drying, there is produced the commercial form of this valuable pigment. It is stable, being unattacked by acids or alkalies, and has a specific gravity of 4.4. Under the microscope, both by polarized and transmitted light, the sharp angles of the particles appear very distinct, with no tendency to mass into a compact form. Although transparent in oil, it is valuable in moderate percentage in a ready-mixed paint.



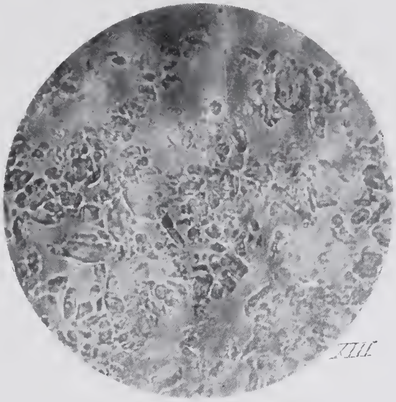
BARIUM SULPHATE (BLANC FIXE).

Blanc fixe is the precipitated form of barium sulphate, resulting from the action of soluble barium salts on soluble sulphates. The specific gravity (4.2) of this compound is lower than that of barytes. Possessing greater opacity in oil, is of more value as a paint pigment for some purposes. It comes in for its greatest use as a base on which to precipitate lake colors. The very fine particles show a slight tendency to agglomerate.



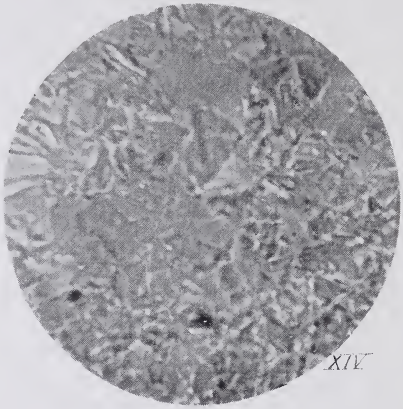
CALCIUM CARBONATE (WHITING).

The natural form of calcium carbonate, prepared from chalk, has a much higher specific gravity (2.74) than that of the artificial form (2.5) prepared by the precipitation of calcium carbonate. This pigment finds wide use in distemper work and for the manufacture of putty. It is used in small percentage in many ready-mixed paints. The photomicrograph of the pigment shows the presence of many large particles.



CALCIUM SULPHATE (GYPSUM).

The mineral gypsum, consisting of calcium sulphate and about 21 per cent. of water of combination, is sometimes used as a paint pigment after grinding and dehydration. Being slightly soluble in water, it has a tendency to pass into solution when exposed to atmospheric agencies. It lacks hiding power in oil. Its specific gravity is 2.3. As in the case of all pigments prepared directly from mineral substances, the many sized and shaped particles appear clearly when enlarged.

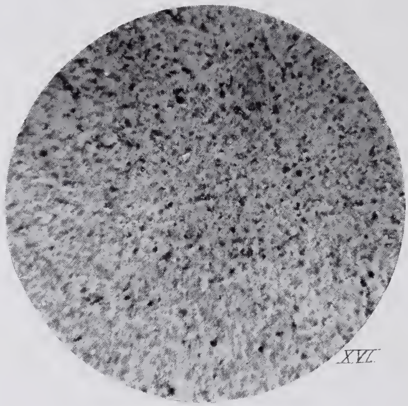


SILICA (SILEX).

This white pigment possesses great tooth and spreading properties. It is of great use as a wood filler and as a constituent in combination paints. It wears especially well when used in combination with zinc oxide and white lead. Its purity often approaches 97 per cent. It is inert to all mixed pigments, making the paint coating more resistant. The particles when enlarged are seen to have sharp angles and are not uniform in size, which accounts for its marked tooth and properties.

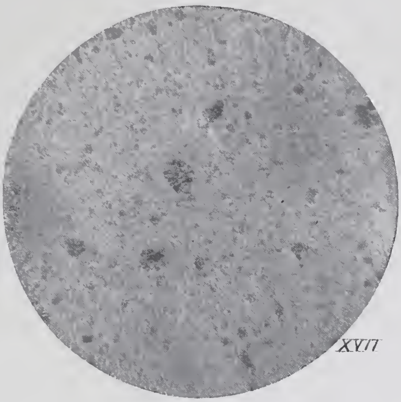
ALUMINUM SILICATE (CHINA CLAY).

China clay, or aluminum silicate, is a permanent and valuable white pigment showing very little hiding power in oil. It is found widely distributed in granitic formations. It is very stable, with a gravity of 2.6. Particles are found in many shapes and sizes, showing many sharp and definite angles.



OCHRE.

Ochre is a hydrated ferric oxide permeating a clay base. It has a specific gravity of about 3.5, and a decidedly golden yellow color. A good quality should contain 20 per cent. or over of iron oxide. The particles of this pigment are flocculent and very uniform in appearance.



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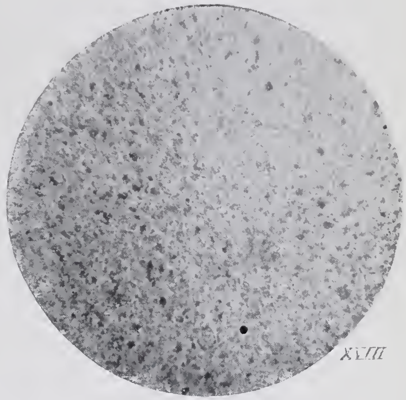
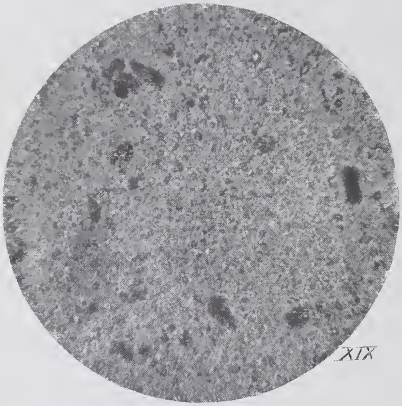


BURNT

SIENNA.

Sienna, like umber, is essentially a silicate of iron and alumina, containing manganic oxide. It contains, however, a lower percentage of the latter than in the case of umbers. The photomicrograph of the burnt variety shows clearly the fine condition of the pigment, while large particles are present in the raw variety.



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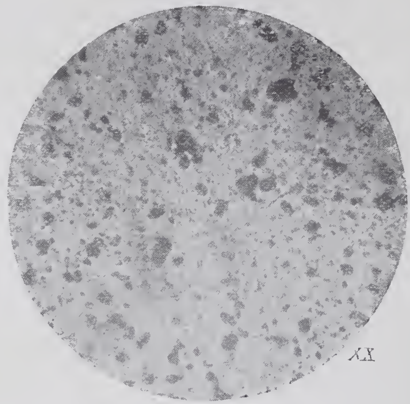
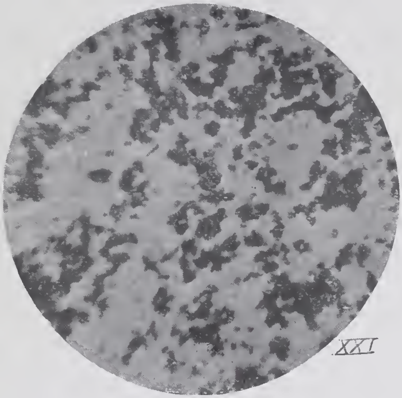


BURNT

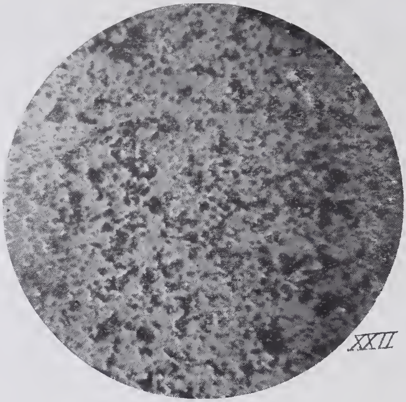
UMBER.

Umber, another naturally occurring pigment, consists of iron and aluminum silicates, containing varying proportions of manganic oxide, its color and tone varying according to the percentage of the latter. The raw variety is drab in color, which in burning changes to reddish brown. A marked percentage of large-sized particles exist in this pigment.



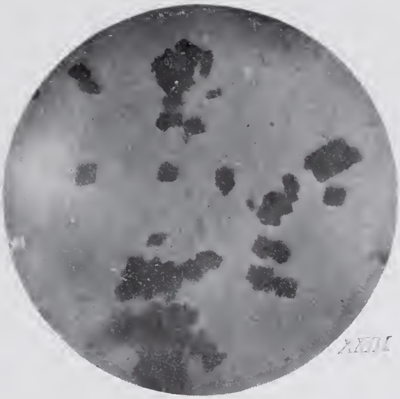
INDIAN RED.

Indian red is the term applied to natural hematite ore pigments and to those produced by the roasting of copperas (iron sulphate). They generally contain 95 per cent. or more of iron oxide, with varying percentages of silica. The pigment is heavier (specific gravity 5.2) than that of Metallic Brown. The crystalline, mineral-like structure of the particles differ greatly from the amorphous particles of Metallic Brown.



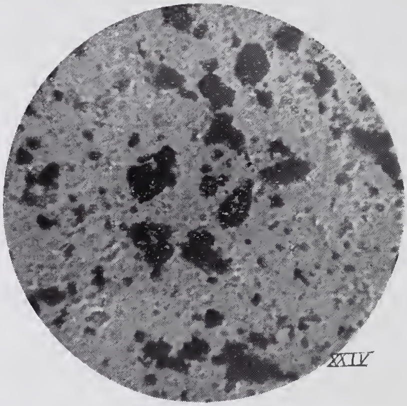
METALLIC BROWN.

The natural hydrated iron oxide or carbonate as mined largely in Pennsylvania, yields, when roasted, a sesquioxide of iron known as Metallic Brown. It contains a high percentage of alumina and silica, and has a characteristic brown color with a gravity of 3.1. It finds wide application as a pigment for protective purposes. The particles when enlarged show the usual appearance of a natural compound which has been roasted and ground.



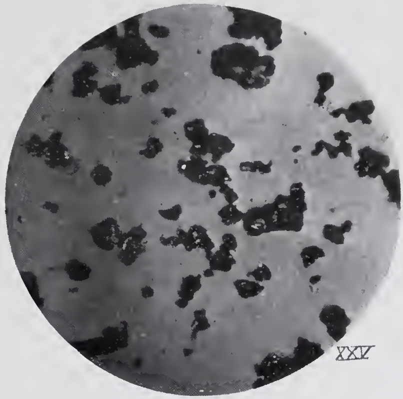
BASIC LEAD CHROMATE (AMERICAN VERMILION).

By boiling white lead with chromate of soda and subsequently treating with small quantities of sulphuric acid, American vermilion, or basic lead chromate, is prepared. It contains 98 per cent. of lead compounds, frequently free chromates, and has a gravity of 6.8. The particles appear granular and large, frequently assuming a square structure. This pigment is an excellent protector of iron and steel and is distinctly inhibitive in all its characteristics.



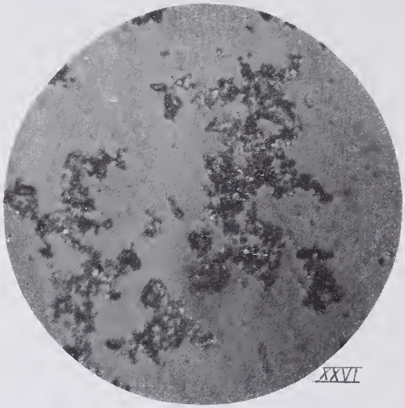
RED LEAD.

By the continued oxidation of litharge in reverberatory furnaces, red lead is produced as a brilliant red pigment with a specific gravity of 8.7. It has found wide application as an inhibitive pigment for the protection of iron and steel. In many cases the admixture of red lead with other pigments is of great value. The pigment particles appear to be of many sizes, showing a slight tendency to form a compact mass.



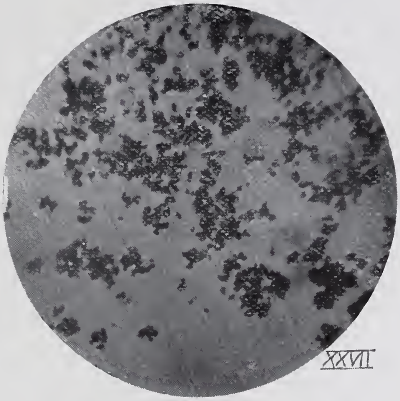
PARANITRANILINE.

Paranitraniline, used as a paint pigment, is prepared by diazotizing paranitraniline in hydrochloric acid by means of sodium nitrite in the cold. This compound is rendered insoluble when precipitated directly on barytes, by acting on it with an alkaline solution of beta naphthol. It is the most stable and permanent bright red organic pigment which the paint manufacturer uses. The particles of this pigment appear in various sizes, due, no doubt, to a massing of the particles in the precipitation process.



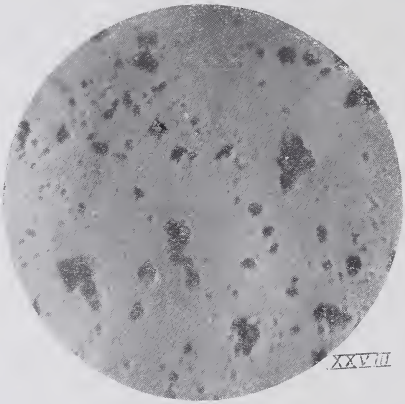
CHROME YELLOW.

The neutral chromate of lead, made from either the nitrate or acetate of lead and chromate of soda, finds large use as a tinting pigment. It has a specific gravity of 5.8 and often contains occluded impurities. When precipitated on a white pigment base, various trade names are given to it. The microscope shows clearly the physical character of this pigment.



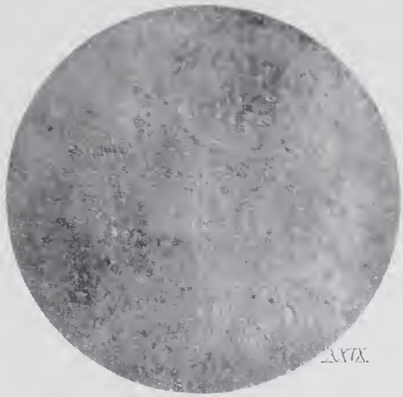
ZINC CHROMATE.

This pigment is made either from zinc salts and bichromate of potash or zinc oxide heated with chrome salts, frequently in the presence of acid. It is an extremely valuable inhibitive pigment when properly prepared, and exerts its influence even when present in very small percentages. Free chromates and uncombined zinc oxide are usually present. The particles are flocculent in appearance and show a decided tendency towards segregation.



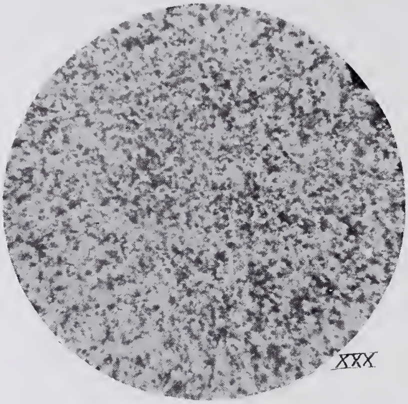
PRUSSIAN BLUE.

On oxidizing the precipitate resulting from the interaction of solutions of prussiate of potash and copperas (iron sulphate), Prussian blue as used in the paint trade is prepared. It has a specific gravity of 1.9. Its inhibitive value is high, and it presents a glossy appearance, even after long exposure. The pigment shows an amorphous structure, the particles varying greatly in size.



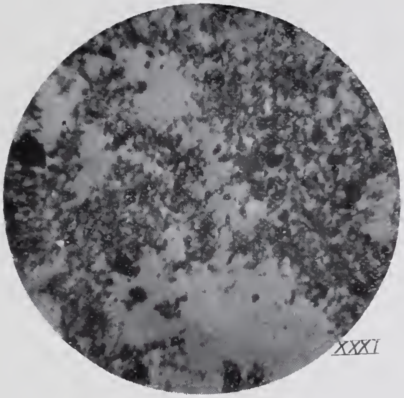
ULTRAMARINE BLUE.

This bright blue pigment is prepared by burning silica. China clay, soda ash and sulphur in pots or furnaces. It has a specific gravity of 2.4. It is of little value as a paint pigment, on account of its sulphur content, which causes darkening when mixed with lead pigments and corrosion when applied to iron or steel. The darkness of the photo graph is due to the massing of the pigment particles.



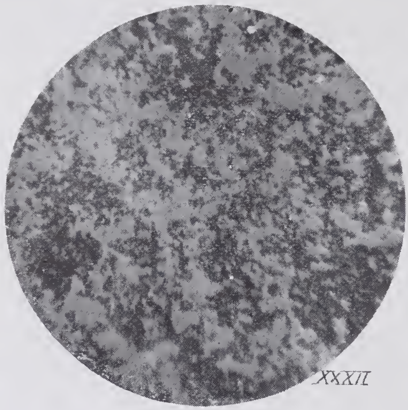
CHROME GREEN.

Chrome green is prepared as a paint pigment from nitrate of lead, Chinese blue and bichromate of soda. It has a gravity of 4 and is liable to contain small traces of lead salts. Its inhibitive value is low. The particles when magnified appear very fine and flocculent. This color is often precipitated on pigments, such as barytes, which does not reduce its tone.



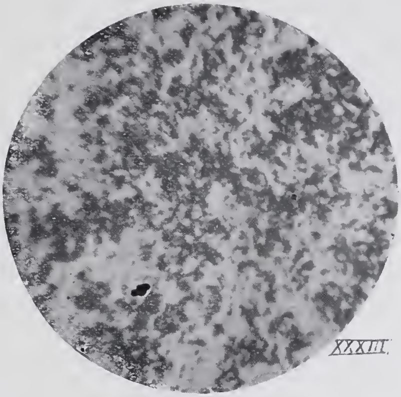
BONE BLACK.

By grinding the carbonaceous matter resulting from the charring of bones, in iron retorts, the pigment bone black is prepared. It contains about 15 per cent. of carbon and 85 per cent. of calcium phosphate. It has a gravity of 2.7. Comparatively large particles of charred bone can be seen scattered throughout the mass, resulting from the difficulty of grinding to a uniform size. As an inhibitive, it has a fairly high value.



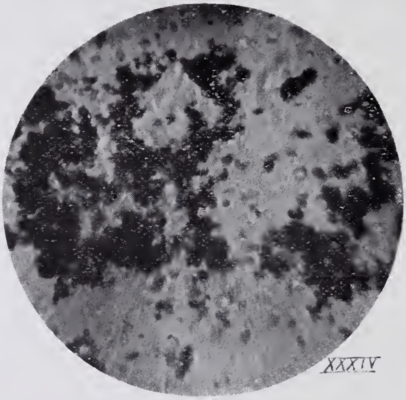
CARBON BLACK.

This form of very pure carbon results from the combustion of natural gas. Its gravity, 1.09, is lower than that of lampblack, which shows a gravity of 1.8. It is used in much the same way and for the same purposes as lampblack. In physical appearance it shows great similarity to the particles of lampblack.



LAMPBLACK.

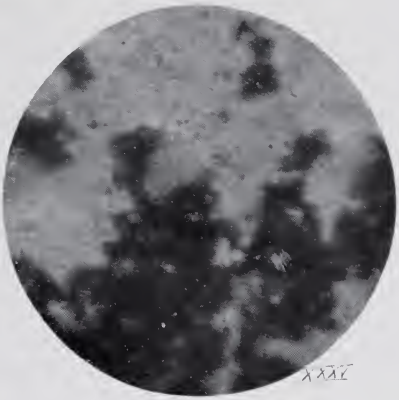
This pigment, made from the combustion of oils, consists very often of more than 99 per cent. carbon. It has wonderful tinting value. As an inhibitive paint, it has little merit, although it serves well when used as a top-coat pigment. The particles show a fine, fibrous structure with a tendency toward agglomeration. They differ greatly in physical appearance from those of either graphite or bone black, being exceedingly more uniform than the latter.



XXXIV

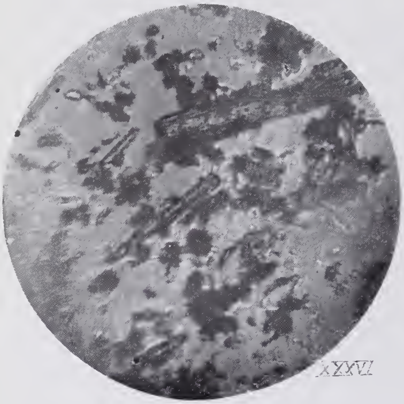
GRAPHITE.

Graphite, both in the natural and artificial form, contains impurities such as silica, iron oxide and alumina, but the natural form has a much greater percentage of these foreign materials, in some cases as high as 40 per cent. Graphite is usually mixed with other pigments, such as red lead and sublimed blue lead, thus serving better as a paint coating. Its use as a prime coating for steel should be avoided, as it tends to stimulate corrosion. The difference in physical appearance of the various carbon pigments is interesting, as each pigment has characteristics of its own. In graphite we find a great tendency toward agglomeration or massing of particles.



MINERAL BLACK.

Mineral black is a pigment made by grinding a black form of slate. It contains a comparatively low percentage of carbon and consequently has low tinting value. It finds use as an inert pigment in compounded paints, especially for machine fillers. The pigment has a flocculent appearance, the particles showing a strong tendency to mass.



ASBESTINE AND WHITING

SILICA AND ASBESTINE

Two combination paint pigments are here given, to show the various pigments as they appear under the microscope, when in combination.

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Proceedings of the American Society for Testing Materials—11th Annual Meeting.

Quantitative Chemical Analysis by Electrolysis —*Classen-Boltwood*

Report of Tariff Committee, Paint Manufacturers' Association of the United States, 1909.

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The Theory and Practice of Enamelling on Iron and Steel —*Grünwald-Hodgson*
The Volatile Oils —*Gildmeister and Hoffman*
Transactions of the American Electrochemical Society, 1909.

Pamphlets

- Corrosion of Fence Wire —*A. S. Cushman*
- The Analysis of Turpentine by Fractional Distillation with Steam —*Wm. C. Geer*
- The Corrosion of Iron —*A. S. Cushman*
- Some Technical Methods of Testing Miscellaneous Supplies —*P. H. Walker*

Periodicals:

- American Paint and Oil Dealer
- Chemical Abstracts
- Drugs, Oils and Paints
- Journal of Industrial and Engineering Chemistry
- Journal of the American Chemical Society
- Journal of the Society of Chemical Industry
- Metallurgical and Chemical Engineering
- Oil, Paint and Drug Reporter
- The Canadian Painter and Decorator
- The Decorator
- The Master Painters' Journal
- The Painters' Magazine

Publications of the Scientific Section

EDUCATIONAL BUREAU

PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES

Bulletin Number

Preliminary Booklet—Addresses on Paint, Delivered Before the Michigan Chapter, American Institute of Architects, 1907. (*Out of print.*)

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25—Report on Examination of North Dakota Test Fences.

Special Bulletin—Scientifically Prepared Paints and Laws Governing Their Manufacture. *By Henry A. Gardner.*

An Exhibition of Certain Analogies Governing the Manufacture of Concrete and of Paint. *By R. S. Perry.*

26—Second Annual Report on Wearing of Paints Applied to Atlantic City Test Fence.

27—Second Annual Report on Atlantic City Steel Test Fence

28—Second Annual Report on Wearing of Paints Applied to Pittsburg Test Fence.

29—The Properties and Structure of Certain Paint Pigments. *By H. A. Gardner and John A. Schaeffer.*

SPECIAL BULLETIN

for Engineers, Architects and Master Painters

SCIENTIFICALLY PREPARED PAINTS

AND LAWS GOVERNING THEIR MANUFACTURE

By HENRY A. GARDNER

Presented before the International Association of Master House Painters and Decorators of the United States and Canada, at Detroit, Mich., February 9, 1910.

Presented before the American Chemical Society, Pittsburg, Pa., February 17, 1910.

SCIENTIFIC SECTION—EDUCATIONAL BUREAU
HENRY A. GARDNER, Director
PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES
3500 Grays Ferry Road, Philadelphia, Pa.

Scientifically Prepared Paints

and Laws Governing Their Manufacture

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SCIENTIFIC SECTION—EDUCATIONAL BUREAU
HENRY A. GARDNER, Director
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CONSULTING BOARD OF SCIENTIFIC SECTION

PREFACE

THIS paper was presented at the Twenty-sixth Annual Convention of the International Association of Master House Painters and Decorators of the United States and Canada, held at Detroit, Michigan, February 8th to 10th, 1910. This paper was again presented before the Pittsburg Chapter of the American Chemical Society on February 17, 1910.

Preliminary to the reading of this paper, nearly 200 lantern slides, showing the laboratories of the Scientific Section, the various test fences at Atlantic City, Pittsburg and North Dakota, and other tests, including microphotographs of each formula applied to the fences, were presented. As the slides were thrown on the screen, a general outline and description of the tests and methods used in field and laboratory inspection was given by the writer.

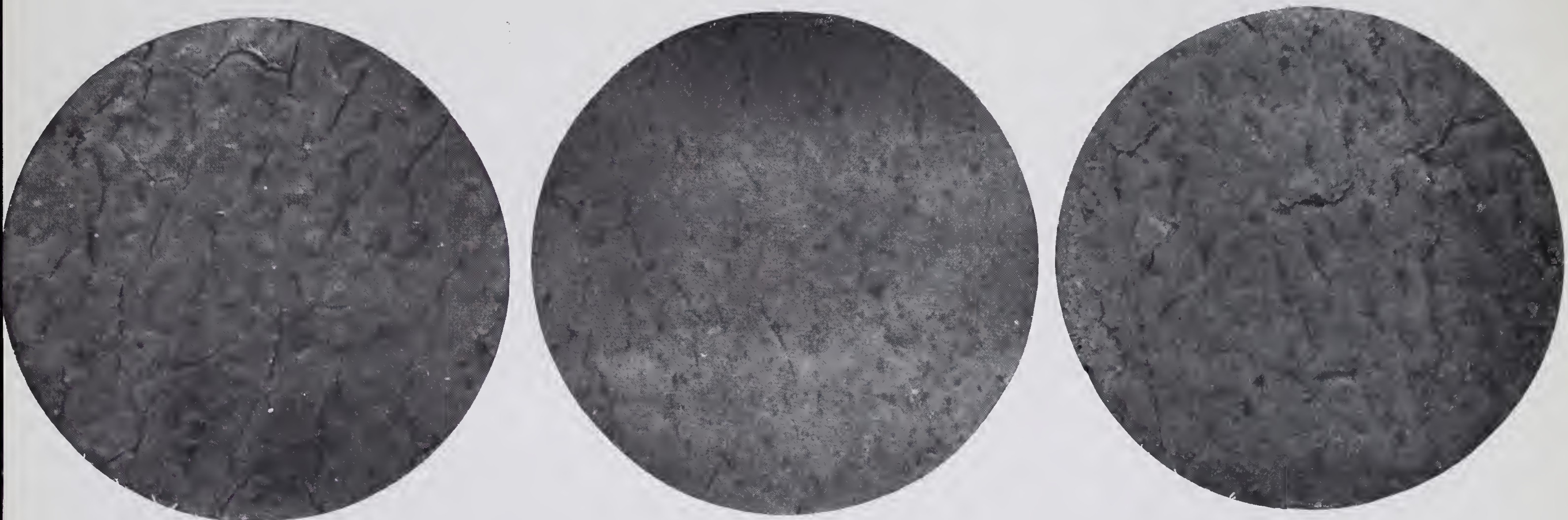
HENRY A. GARDNER

Director Scientific Section

Microphotographs of three Corroded White Leads showing checking and chalking after fifteen months' exposure on Atlantic City Test Fence.

FORMULAS 36, 37 AND 38
100% WHITE LEAD

Microphotographs illustrating the general good condition of the scientifically prepared combination type formulas on the Atlantic City Test Fence. All microphotographs were taken at the same magnification from the painted panels. Panels had been exposed on fence fifteen months.



FORMULAS 8, 17 AND 35

Made of White Lead, Zinc Oxide and Reinforcing Pigments.

ATLANTIC CITY TEST FENCE

PITTSBURG TEST FENCE

NORTH DAKOTA TEST FENCE

For reports on these Test Fences see Bulletins 16, 17 and 25, issued by Scientific Section, Paint Manufacturers' Association.

SCIENTIFICALLY PREPARED PAINTS AND LAWS GOVERNING THEIR MANUFACTURE

By HENRY A. GARDNER

It has been said by a noted authority that all knowledge is within the scope of scientists and that every piece of information that is obtainable should be utilized. The same authority states that a classified accumulation of facts, properly considered, allows the formation of conclusions. It is in this way that laws are formulated, upon which are based the manufacturing processes of modern industries.

Had the great pioneers of scientific thought been deterred by lack of complete knowledge from formulating laws, the science of today would have been poverty-stricken where it is now rich. The benefactors of science have been those who, from intimate knowledge of relatively few concurrent facts, have been able, by the bold use of a trained imagination, to grasp the governing principle. Marsh from a thigh bone and a tooth will reconstruct the Dinosaur. Van't Hoff from observation of electrical conductivities and osmotic pressures will leap to the identity in properties of substances in solution and gases.

Law after law propounded by the great heroes of science has been amended, modified and replaced by the discovery of fresh facts; but their work lives, their laws have served their turn by explaining the facts known to them, and when additional facts required a broader generalization, their successors, standing

upon their shoulders, have described the wider horizon.

Perry's formulation of the Law of Minimum Voids in a paint coating, and the analogy which has been drawn between a scientifically-prepared paint and a well-proportioned concrete, was the result of genuine scientific thought following observation and experimentation.

The geologist who observes the fin of a fish embedded in a mountain rock forms a hypothesis from his observation. If his hypothesis will stand close examination, and is in agreement with other observed facts, he is in a position to form a conclusion. Verification of the accumulated observation leads him to formulate laws. In this way the great physicists and chemists have given us many important laws, such as the law of specific gravity, the law of chemical equivalents, etc.

From a series of accumulated facts and observations, it is possible by deductive reasoning to formulate laws. For instance, it has been found that in the mixing of paint and in the mixing of concrete, a number of particles of different size and composition give the greatest impermeability and the lowest percentage of voids. It has also developed that such mixtures give the greatest strength. From these and other observations it is possible to formulate laws governing the voids and strength of these two materials.

By deductive reasoning, laws are utilized to infer what will take place in certain cases. Thus, if we have a law stating that in the setting of concrete a disturbance after the initial set causes a loss of strength, by utilizing this law we can predict a loss of strength in a paint coating that is drying by oxidation if the surface is subject to disturbance after the linseed oil is partly converted to semi-solid linoxyn.

It is admitted that analogies are not always safe

to draw conclusions from, but it surely is no fallacy in reasoning to draw analogies between these two materials, when they resemble each other in nearly all their characteristics. When the analogy is very close, we should then carry on our processes of reasoning and endeavor to formulate laws so that our observations may be made more useful.

The testing engineer makes a briquet of neat cement and puts it under his physical testing apparatus, where he finds it to possess a certain definite tensile and compressive strength, a certain amount of elasticity and other properties. The cement engineer knows that this neat cement briquet is to some extent impervious. He does not stop, however, at this point, but proceeds further in his investigations. He adds a proportion of sand or stone to the cement, and if the proportion be suitably adjusted, he obtains a briquet showing still greater strength and one that is less permeable, or, in other words, that has fewer and smaller voids. He experiments with the relative water tightness of cements and finds that the addition of a definite proportion of hydrated lime* gives still greater impermeability. His results with magnesia and other minerals, fineness of grinding of the cement, proper grading of the sand for sharpness of particle, and the quality of the stone that he is using, all give him information from which he draws his hypothesis regarding that certain, well-defined composition that is most valuable.

The ceramic or pottery engineer recognizes laws which govern his use of materials, in a like way. For instance, †Parr, Ernest and Williams, from their experiments in the use of finely-divided silica, have

* The action of hydrated lime in concrete may be somewhat like the action of gum in paint vehicles. In both cases greater impermeability is given.

† *Jour. Indus. and Engineer. Chem.*, Vol. 1, No. 10, Oct., 1909, p. 692.

ascertained what are the most satisfactory proportions of lime and silica to use together. They have found that when magnesia is added to the mixture of lime and finely-divided silica, in the right proportion, even better results were obtained in some cases. Further experiments demonstrated to these engineers that the introduction of sharp sand in certain percentage into the mixture of lime and silica gave much higher tensile strength. Experiments with fibrous materials like asbestos showed these materials to be beneficial up to about 12%. Here again in another branch of technology we have the call for difference in constitution as well as difference in particle size of the raw material used.

In a like way, the paint chemist makes a paint film of one pigment and he finds that it shows, when tested on the physical testing apparatus, a certain elasticity and abrasion resistance. He tests it for excluding value and finds the extent of its resistance to moisture and gases. He now makes a film of the same pigment reinforced with two or three other pigments of different chemical characteristics, as well as of different particle size, and finds that greater elasticity, strength, and excluding properties have been obtained.

The resemblance between a neat or straight cement and a paint made of one pigment, on the one hand, and between concrete and the two or more pigment paints, on the other hand, is vividly brought forth at this point, and justifies a hypothesis. Before forming laws, however, or hasty conclusions, the paint chemist goes into the field with the two paints that he has prepared, and he places each upon test boards or upon buildings, making a fair and careful test. After sufficient time has elapsed, he examines the two surfaces and finds that the paint made of one pigment has seriously failed in those properties which are requisite, while the paint made of more than one

pigment is justifying the hypothesis which he has formed. Thus from observation and experimentation, a classified accumulation of facts is obtained as a basis for conclusions.

Truly, if such methods are followed in the manufacture of paint, the manufacturer is justified in using the term "Scientifically Prepared Paints," or "Engineering Paints."

It is true that concrete voids may be defined as spaces filled with air or water throughout a mass of concrete. It is generally acknowledged that true paint voids are voids between the pigments in the paint coating, filled with dried linseed oil. It has been stated that pigments of heavy specific gravity would naturally possess smaller voids than lighter pigments. This might be true of dry pigments where accidental voids would be present, but with a paint where the pigments are ground thoroughly in oil and afterward spread on a surface and properly brushed in, it is clearly evident that the lighter pigments have their proper place and function to form in making a paint coating as voidless as possible. With lubrication (brushing in) accidental voids are destroyed and only those voids remain that are a result of improper grading of the pigments.

The coarse particles of a paint pigment have been compared to the spawl or rock in concrete, the sharp-toothed particles with the broken stone, and the very fine or fume pigments to the sand.

The vehicle of the paint, that is, the linseed oil and thinners, may be compared to the vehicle or cementing material of the concrete; that is, the water and the Portland cement.

The percentage of spawl or large rock in concrete is subject to the thickness of the work and not very great excepting where the concrete is very thick. With a paint coating which is only one-thousandth of an inch thick, it is also necessary to limit the per-

centage of coarse pigments. In fact, it has been stated by Thompson that the relatively small particles should predominate in a paint and that if corroded white lead could be improved it would be by increasing the percentage of fine particles. The paint engineer agrees with both these conclusions and forthwith adds to corroded white lead a percentage of very fine pigments such as zinc oxide, or sublimed white lead, obtaining a more perfect paint.

Perry has conceived of a paint coating as a flat arch in which the piers or supports are composed of the larger sized pigments. White lead has the requisite sized particles to act as these supports, but not always in the proper percentage. Furthermore, because of the chemically active nature of the white lead particles, saponification of the oil in which they are ground, causes early decay and destruction of the arches. Now, to prevent this action, the manufacturers add an inert pigment containing particles of relatively large size, thus breaking up the mass action of the lead. The piers and supports for the arches are now stable and preservation of the arches is obtained.

Let us leave the subject of concrete now and its analogy to properly-prepared paint and take up a few of the properties of painting materials.

There is a consensus of opinion among paint scientists, including the defenders of corroded white lead in oil, that this material should not be used with pigments containing sulphur, because of the blackness that would result through the formation of sulphide of lead. It is even said that white lead is a good indicator of sulphuretted hydrogen and should be used where putrefaction and unhealthful conditions obtain. The smell emanating from boiling cabbage which we are all familiar with, and the odors from the kitchen and stable, are generally caused by hydrogen sulphide. The odor is so evident that a delicate paint pigment

such as corroded white lead is not required for detection.

It has been said by a noted white lead chemist that sufficient hardness to prevent chalking may be obtained with corroded white lead, when desired, by giving the top coating a flat finish probably with a high turpentine reduction. It has also been stated that the surface of such a paint coating will chalk early, leaving a rough surface which will probably be checked, and that this surface is of a kind suitable for repainting. Can we accept this statement, after looking at the microphotographs of a white lead coating, one year old, on which the crests and checks on this soft pigment are so deep that the bare wood is exposed?

The apparent turning in of the edges in the checking of corroded white lead may be partly accounted for by Heckel's theory of the causes of disintegration. He assumes that certain pigments in the paint film, either by reaction with the vehicle or with the gases of the atmosphere, undergo changes of chemical composition resulting in an increase of volume, which causes strains in the coating. If the coating is brittle at the time this expansion occurs, it will not only rupture, but the edges of the ruptures will break away; if the film be still tough, the edges of the rupture will turn outward.

Regarding the adjusting of paint to suit various conditions, the writer wants to agree with *Dewar where he states that "The meeting of good, fair or bad conditions in new or old work is not to be regulated by the changes in the pigments, as conditions can only be met and overcome by the discriminating use of the vehicle, the proportioning of oil and turpentine to meet requirements." This statement of

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* The Best Materials in Combination and Otherwise to Produce the Best Practical Results Possible in Exterior and Interior Painting.

Dewar's is one of the most important ones to the painting craft that has ever been announced, and deserves a place with the statements of the late Dr. Dudley regarding the theory and pratical use of inert pigments. Therefore, after the proper pigment formula has been decided upon, and, as Mr. Dewar states, "A mixture of lead and zinc is materially benefited by 8 to 10% of inert material," we obtain a base upon which we can make our paint to suit various conditions. Such a blend of pigments might be called a composite type of paint.

It has been stated that white leads are surely the basis of all good paints, and that the man who recognizes this fact is conducting his business upon lines where purity is synonymous with excellence. The reputable manufacturers agree with this statement to a great extent and for exterior use nearly every proper composite type of paint is based on the use of white lead and zinc oxide, and until more perfect white opaque pigments are discovered, they will be used for this purpose.

You have heard that copper is added to gold, and zinc and tin are added to copper to form alloys that are harder, more resistant to wear and possessed of physical qualities not obtainable from the gold or copper alone. You have read that carbon, vanadium and other products are added to iron to produce a metal which has greater strength. You know that the rubber manufacturers add zinc oxide, white lead, barytes, silica, magnesia and whiting to rubber to obtain a product for the making of automobile tires that will wear longer than pure rubber. In the same way, the paint manufacturers add a percentage of zinc, barytes, silica, asbestine, or other pigment, to the white lead which is the basis of their paints, and thereby strengthen and lengthen the life of the product.

CATALOGUE

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Petroleum and Its Products—2 Vols. —*Sir Boverton Redwood*

A Treatise on its Distribution, Occurrence, Physical and Chemical Properties, Refining and Uses

Handbook on Petroleum —*Thomson Redwood*

A Treatise on the Industrial Use of its Products.

Simple Methods for Testing Painters' Materials —*A. C. Wright*

Letters to a Painter —*Ostwald-Morse*

On the Theory and Practise of Painting

Iron Corrosion and Anti-Corrosive Paints —*L. E. Andes*

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Used in the Manufacture of Paints, Colors, Varnishes and Allied Preparations

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A Practical Handbook Treating of Linseed Oil, Boiled Oil, Paints, Artists' Colors, Lamp Black, and Printers' Inks

Manufacture of Mineral and Lake Pigments —*J. Bersch*

Containing Directions for the Manufacture of All Artificial Artists' and Painters' Colors, Enamel Colors, Soot and Metallic Pigments

Chemistry of Paints and Painting —*A. H. Church*

Painters' Laboratory Guide —*G. H. Hurst*

A Handbook on Paints, Colors and Varnishes

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House Painting —*A. H. Sabin*
The Microscope —*S. H. Gage*
A Treatise on Color Manufacture —*Zerr & Rubencamp*
Outlines of Qualitative Chemical Analysis —*Gooch & Browning*
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A Practical Handbook for Paint Manufacturers
The Chemistry of Pigments —*Parry & Coste*
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A History of Decorative Art —*W. Norman Brown*
Notes on Lead Ores —*Jos. Fairie*
Their Distribution and Properties
Technology of Paint and Varnish —*A. H. Sabin*
Oil Chemists' Handbook —*Hopkins*
Proceedings of the American Society for Testing Materials—11th Annual Meeting.
Chemiker-Kalendar—1908.
Principles of Reinforced Concrete Construction —*Turneaure & Maurer*
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The Lead and Zinc Pigments —*C. D. Holley*

Transactions of the American Electrochemical Society, 1909.

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Bulletins of the Census Bureau.

Paints for Steel Structures —*Houston Lowe*
The Chemistry of Photography —*Raphael Meldola*
One Thousand More Paint Questions Answered.

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